VARIAN ASSOCIATES - Bomac Division
Salem Road
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BL-221 70 Gc MAGNETRON PRODUCTION ENGINEERING MEASURES PROGRAM FINAL REPORT

Section 1 and 3 - Volume 1
6 August 1961 through 6 May 1964

CONTRACT NO: DA-36-039-SC-85974

CONTRACTING AGENCY: U. S. Army Signal Supply Agency
225 South Eighteenth Street
Philadelphia 3, Pennsylvania

ATTENTION: Contracting Officer
PEM and Facilities Procurement Branch
Procurement Management Division "C"

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VARIAN ASSOCIATES - Bomac Division
Salem Road
Beverly, Massachusetts

BL-221 70 Gc MAGNETRON PRODUCTION ENGINEERING MEASURES PROGRAM FINAL REPORT

Section 1 and 3 - Volume 1
6 August 1961 through 6 May 1964

OBJECT:	To investigate minor constructional modifications in the present design, evaluate a pre-production run of thirty (30) tubes and determine manufacturing facilities capable of producing fifty (50) tubes per month.
CONTRACT NO:	DA-36-039-SC-85974
ORDER NO:	6029-PP-61-81-81
SIGNAL CORPS TECHNICAL REQUIREMENTS:	SCS-70 dated 23 September 1959
PREPARED BY:	Robert C. Sibley Manager, Power Tube Product Development

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ILLUSTRATIONS

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ABSTRACT

Production Engineering Measures were applied to the 70 Gc magnetron developed on a previous R and D contract.

The four major changes in the tube and process design were (1) a change from a glass output window to a ceramic output window, (2) an improved integral cathode centering device, (3) additional finish treatment of assembly to prevent corrosion in storage and (4) increased vacuum and other cleaning processing of internal parts to improve life.

Studies were made on frequency tunability, and integral ion pump appendage modifications. These were not incorporated.

A specification in the MIL Format was proposed and approved and the tube was registered under the number 8558.

A hobbed anode manufacturing facility and capability was established at Bomac as a second source to other such facilities. Bomac's facility is established to perform hot hobbing and is at present being used to make anodes from 16 to 70 Gc.

Preproduction Approval Testing was performed on five (5) tubes with no failures and the procedures and data are included herein.

According to agreements between Bomac and the Signal Corps, reached after the preproduction approval tests were completed, the pilot run of thirty (30) units was deleted from the program.

PURPOSE

The purpose of this PEM Program was to investigate minor constructional modifications in the BL-221 magnetron design and to set up a manufacturing facility capable of producing at a rate of fifty (50) tubes per month.

Among the constructional design modifications undertaken were:

a) Construction and evaluation of a BL-221 tube with a permanently attached Vac-Ion Pump.

b) Replacement of the present glass output window assembly with a ceramic or sapphire structure.

Four (4) model tubes incorporating the design modifications adopted were delivered to the Signal Corps for evaluation purposes and thirty (40) additional tubes were to be manufactured after approval by the Contracting Agency.

NARRATIVE AND DATA

I. Status of Design Prior to PEM Program

Prior to the initiation of this PEM Program small quantities of tubes could be provided at a manufacturing cost in the order of \$5,000. A group of such tubes were made and delivered on a Signal Corps purchase order. The tubes deteriorated during storage and many had to be replaced. The storage deterioration was found to be due to (1) hydrogen penetration caused by external surface corrosion and (2) mechanical instability of radial cathode position.

The high cost of manufacture was due to several factors. Assembly yield was poor due to poor braze flow, cracked cathode emitters, broken windows and many other lesser reasons. Test yield was poor because of burned out windows, inability to properly center the cathode radially in the anode, improper frequency, low power and moding.

A firm specification could not be prepared at that time, since testing facility and methods had not been adequately developed.

Construction of tubes prior to the PEM Contract was dependent on a single outside source for hobbed anodes.

II. Shelf Storage Life

The problem of short storage life was investigated along two avenues. One studied the feasibility of an integral vac-ion pump appendage and the second studied various tube finishes under heated and humid conditions.

II. Shelf Storage Life (continued)

A. A Vac-Ion Pump Appendage

A special tube magnet was designed to provide the necessary field for the Varian 913-000-2 pump in addition to that needed for the magnetron. The package is shown in Figure 1. The appendage and magnet change caused an increase in tube weight of one quarter pound. A total of eight (8) tubes were built; two of which were standard control tubes and three of which were lost in assembly stages. The two control tubes were tested throughout the program with the regular unintegrated vac-ion pump attached but not running except when a pressure reading was required.

All tubes were held for 1/1-2 months shelf storage and then initiated on life test. Internal tube pressure and test readings were monitored periodically throughout the sequence. Representative data is presented in Figures 2 through 5. The data shows no significant difference between the control tubes and the vac-ion appendage tubes. It is apparent that continuous pumping is not categorically helpful in prolonging the serviceability of the tube as it was designed and processed prior to this PEM Program. A more extensive investigation applied on the present state of design might demonstrate some significant results, but it seems more logical to conclude when taking other facts into consideration that operating life is limited by something other than vacuum degradation.

VAC-ION PUMP
APPENDAGE TUBE

FIGURE 1

VAC-ION PUMP APPENDAGE
TUBE NO. 320

PERIODIC INTERNAL TUBE PRESSURE TESTS

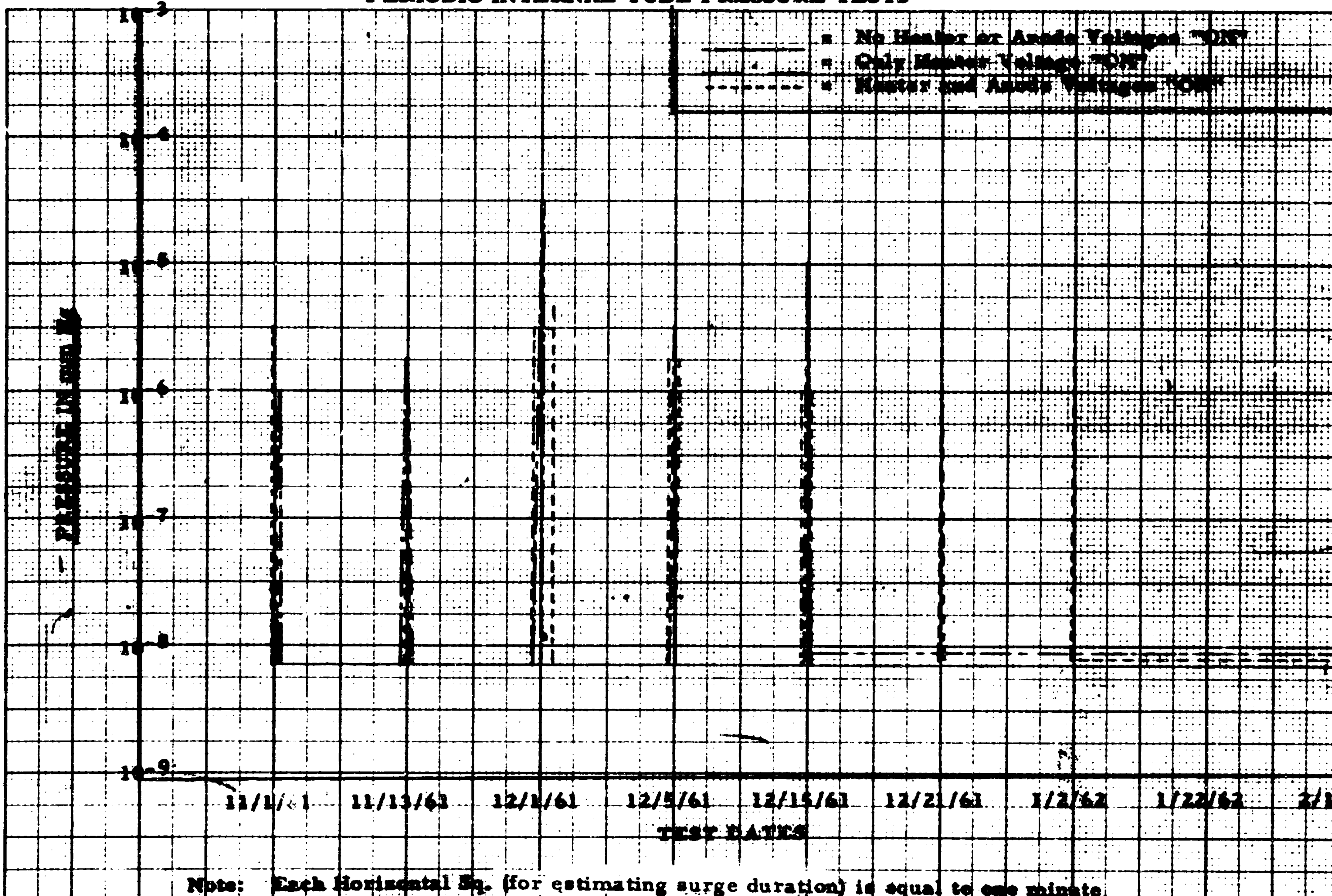


Figure 2

STANDARD DESIGN TUBE
NO. 323

PERIODIC INTERNAL TUBE PRESSURE TESTS

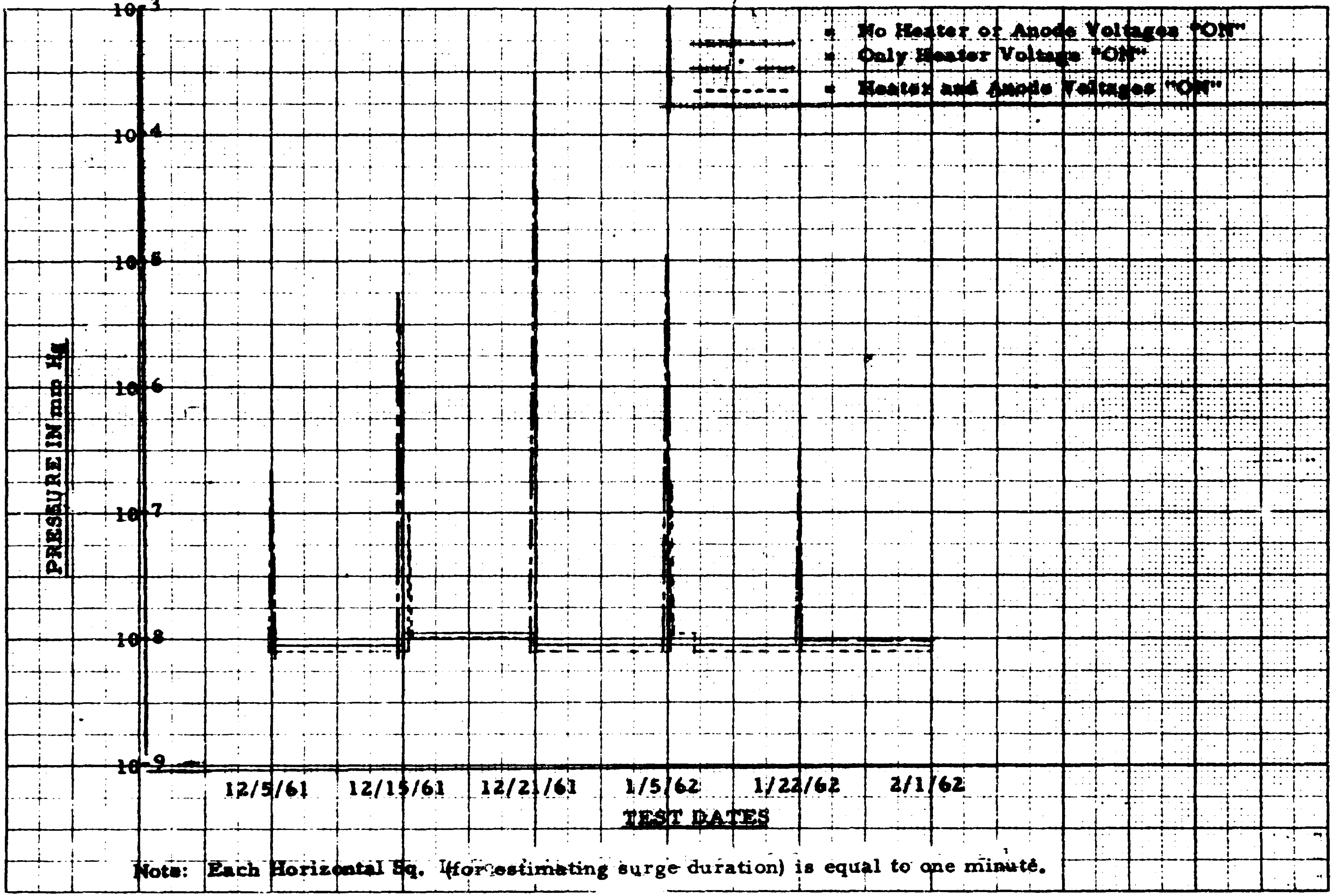


Figure 3

TEST DATA

VAC-ION PUMP APPENDAGE TUBE NO. 320

Test Date	TESTS	Heater Conditions				Input Conditions			Output			Pulse Conditions				Internal tube pressure (mm Hg)	Number of life cycles
		Starting		Operating													
		Eh (V)	Ih (A)	Eh (V)	Ih (A)	i_b (A)	I_b (Ma)	epy (kv)	Po (W)	po (kw)	Fo (kmc)	tp (μsecs)	prf (pps)	du	Type Pulser		
11/1/61	Initial	6.3	2.6	2.0	1.3	9.0	4.5	13.50	7.5	15.0	69.9	0.06	8,400	0.0005	Hard	1×10^{-7}	
11/13/61	Shelf	6.3	2.6	2.0	1.3	9.0	4.5	13.50	6.3	13.0	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	
12/1/61	"	6.3	2.6	2.0	1.3	9.0	4.5	13.50	6.3	13.0	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	
12/5/61	"	6.3	2.6	2.0	1.3	9.0	4.5	13.50	6.3	13.0	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	
12/15/61	"	6.3	2.6	2.0	1.3	9.0	4.5	13.50	6.3	13.0	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	
12/21/61	"	6.3	2.6	2.0	1.3	9.0	4.5	13.50	6.3	13.0	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	
1/2/62	"	6.3	2.6	2.0	1.3	9.0	4.5	13.50	6.3	13.0	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	
1/22/62	"	6.3	2.6	1.5	1.0	9.0	5.2	14.00	8.5	17.0	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	
2/1/62	"	6.3	2.6	1.5	1.0	9.0	5.2	14.00	8.5	17.0	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	
3/1/62	"	6.3	2.6	1.5	1.0	9.0	5.2	14.00	8.0	16.0	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	
3/4/62	"	6.3	2.6	1.5	1.0	9.0	5.1	14.00	7.5	15.0	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	
4/10/62	Life	6.3	2.6	1.5	1.0	9.0	4.5	13.95	5.5	11.0	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	0
4/11/62	"	6.3	2.6	1.5	1.0	9.0	4.5	13.95	5.0	10.0	69.7	0.06	8,400	0.0005	Hard	1×10^{-8}	52
4/13/62	"	6.3	2.6	1.5	1.0	9.0	4.5	13.95	5.3	10.6	69.8	0.06	8,400	0.0005	Hard	1×10^{-8}	108
4/16/62	"	6.3	2.6	1.5	1.0	9.0	4.5	14.25	5.8	11.3	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	195

(cont'd. on next page)

Figure 4

BL-221 TEST DATA
VAC-ION PUMP APPENDAGE TUBE NO. 320 (cont'd.)

Test Date	TESTS	Heater Conditions: Starting Eh (V)	Starting Ih (A)	Operating Eh (V)	Operating Ih (A)	Input Conditions: I_b (A)	I_b (Ma)	epy (kv)	Output: Po (W)	po (kv)	Fo (kmc)	Pulse Conditions: tp (μsec's)	prf (pps)	du	Type Pulser	Internal tube pressure (mm Hg)	Number of life cycles
4/18/62	Life	6.3	2.6	1.5	1.0	9.0	4.5	14.35	5.1	10.2	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	266
4/23/62	"	6.3	2.6	1.5	1.0	9.0	4.5	14.55	5.0	10.0	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	400
4/27/62	"	6.3	2.6	1.5	1.0	9.0	5.0	15.10	5.5	11.0	69.9	0.06	8,400	0.0005	Hard	1×10^{-8}	500
4/30/62	"	6.3	2.6	2.1	1.3	9.0	5.0	15.50	4.5	9.0	70.0	0.06	8,400	0.0005	Hard	1×10^{-8}	540
5/2/62	"	6.3	2.55	See Note Below												1×10^{-8}	632

TOTAL LIFE - 586 cycles approximately

Note: At about five amps peak current pav increased to over eighteen (18) kv . This was attributed to loss of cathode emission.

Figure 4 (cont'd)

BL-
TEST DATA

TEST DATA

STANDARD DESIGN TUBE NO. 323

Test Date	TESTS	Heater Conditions: Starting Eh (V)	Starting Ih (A)	Operating Eh (V)	Operating Ih (A)	Input Conditions: i_b (A)	I_b (Ma)	epy (kv)	Output: Po (W)	po (kw)	Fo (kmc)	Pulse Conditions: tp (μsec's)	prf (pps)	Du	Type Pulser	Internal tube pressure (mmHg)	Number of life cycles
12/8/61	Initial	6.3	2.55	1.5	1.0	9.0	5.0	13.8	6.0	12.0	69.80	0.06	8,400	0.0005	Hard	1×10^{-8}	
12/15/61	Shelf	6.3	2.55	1.5	1.0	9.0	5.0	13.8	6.0	12.0	69.80	0.06	8,400	0.0005	Hard	1×10^{-8}	
12/21/61	"	6.3	2.55	1.5	1.0	9.0	5.0	13.8	6.0	12.0	69.80	0.06	8,400	0.0005	Hard	1×10^{-8}	
1/5/62	"	6.3	2.55	1.5	1.0	9.0	5.0	13.8	6.0	12.0	69.80	0.06	8,400	0.0005	Hard	1×10^{-8}	
1/22/62	"	6.3	2.55	1.5	1.0	9.0	5.2	13.8	6.5	13.0	69.80	0.06	8,400	0.0005	Hard	1×10^{-8}	
2/1/62	"	6.3	2.55	1.5	1.0	9.0	5.2	13.7	6.5	13.0	69.80	0.06	8,400	0.0005	Hard	1×10^{-8}	
3/13/62	Life	6.3	2.55	1.5	1.0	9.0	5.2	14.5*	6.5	13.0	69.80	0.06	8,400	0.0005	Hard		0
3/15/62	"	6.3	2.55	1.5	1.0	9.0	5.2	14.5	6.5	13.0	69.80	0.06	8,400	0.0005	Hard		65
3/16/62	"	6.3	2.55	1.5	1.0	9.0	5.2	14.5	7.0	14.0	69.80	0.06	8,400	0.0005	Hard		92
3/19/62	"	6.3	2.55	1.5	1.0	9.0	5.2	14.5	5.5	11.0	69.80	0.06	8,400	0.0005	Hard		207
3/21/62	"	6.3	2.55	1.5	1.0	9.0	5.2	14.6	5.5	11.0	69.80	0.06	8,400	0.0005	Hard		313
3/22/62	"	6.3	2.55	1.5	1.0	9.0	5.2	14.6	5.0	10.0	69.80	0.06	8,400	0.0005	Hard		360
3/23/62	"	6.3	2.55	1.5	1.0	9.0	5.2	14.6	4.8	9.6	69.80	0.06	8,400	0.0005	Hard		406
3/26/62	"	6.3	2.55	1.5	1.0	9.0	5.2	14.7	4.2	8.4	69.80	0.06	8,400	0.0005	Hard		466

(cont'd. on next page)

Figure 5

STANDARD DESIGN TUBE
No. 323 (cont'd.)

		Heater Conditions				Input Conditions			Output			Pulse Conditions				Internal tube pressure (mm Hg)	Number of life cycles
		Starting		Operating													
Test Date	TESTS	Eh (V)	Ih (A)	Eh (V)	Ih (A)	i_b (A)	I_b (Ma)	epy (kv)	Po (W)	po (kw)	Fo (kmc)	tp (μsec's)	prf (pps)	Du	Type Pulser		
3/28/62	Life	6.3	2.55	1.5	1.0	9.0	5.2	14.8	4.5	9.0	69.80	0.06	8,400	0.0005	Hard		566
3/29/62	"	6.3	2.55	Tube moding badly above 8 amps peak								0.06	8,400	0.0005	Hard		598

* Increase in PAV attributed to final packaging of tube in preparation for life testing.

TOTAL LIFE - 584 cycles

Figure 5 (cont'd)

II. Shelf Storage Life (continued)

B. External Finish

The graph Figure 6, and the picture Figure 7, illustrate the effect of temperature and humidity exposure on tubes processed in four different ways.

The method originally used to prevent corrosion during storage was to nickel plate all exposed ferric materials prior to final assembly and before exhaust and bakeout. Pressure readings taken on a control tube stored at 100°F and 95% humidity along with the poor storage life experienced in the field indicate that this plating is insufficient.

Three alternate procedures were tested and each provided adequate protection up to 100°F. None provided protection at 100°C. The three alternate procedures were: (1) increased initial nickel plating, (2) gold plating after exhaust over original thin nickel plating, and (3) nickel plating after exhaust over original thin nickel plating.

In the future when the next tubes are built additional safeguards could be applied. These may include: (1) gas atmosphere or vacuum protection of an original thicker nickel plate during exhaust, and (2) use of primer and finish paint materials prior to magnet assembly.

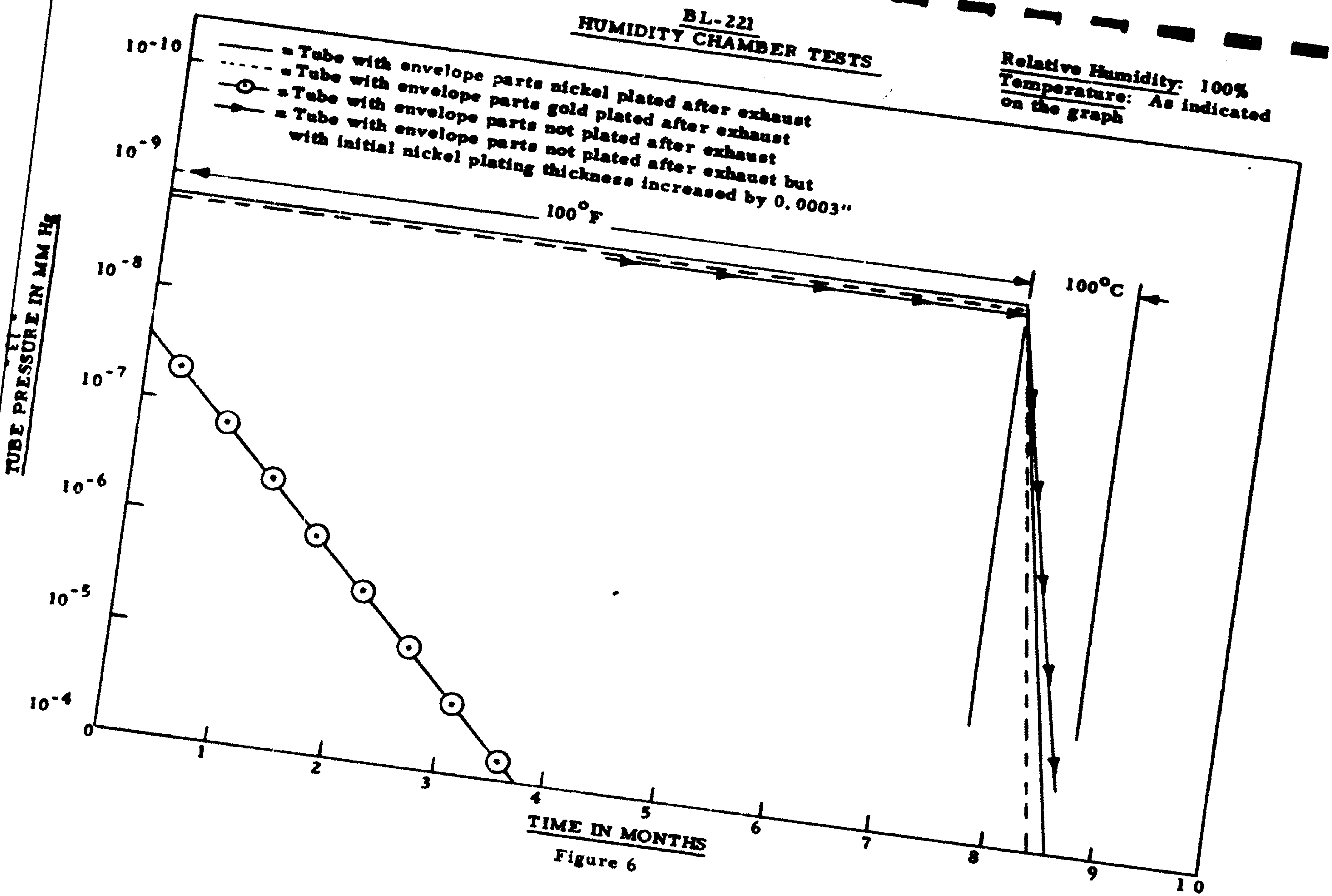
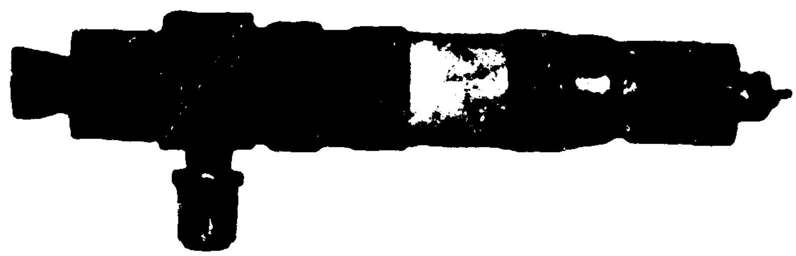
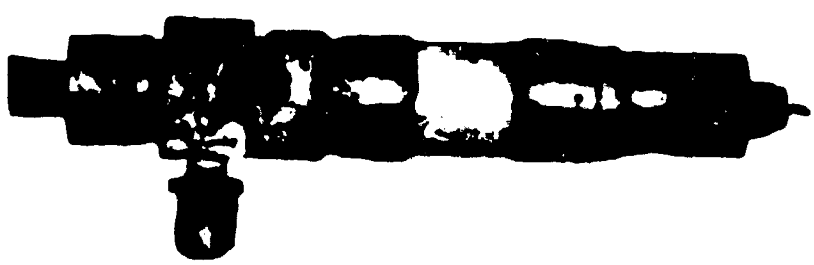

BL-221
HUMIDITY CHAMBER TESTS
Relative Humidity: 100%
Temperature: As indicated on the graph
= Tube with envelope parts nickel plated after exhaust
= Tube with envelope parts gold plated after exhaust
= Tube with envelope parts not plated after exhaust
= Tube with envelope parts not plated after exhaust but with initial nickel plating thickness increased by 0.0003"
100°F
100°C
TUBE PRESSURE IN MM Hg
10-10
10-9
10-8
10-7
10-6
10-5
10-4
0
1
2
3
4
5
6
7
8
9
10
TIME IN MONTHS

Figure 6

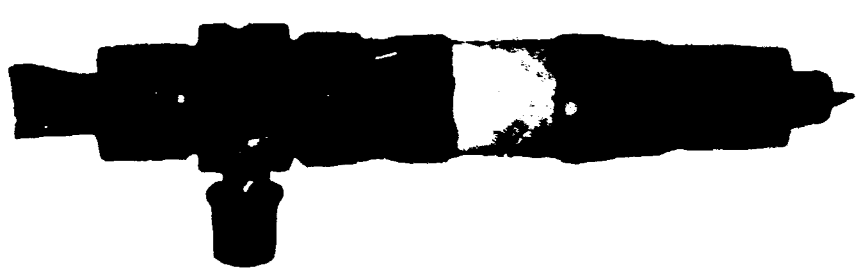
BL-221
MAGNETRONS (BODIES) AFTER EXPOSURE TO HUMIDITY CHAMBER TESTS



Tube with nickel plating
after exhaust



Tube with Gold plating
after exhaust



Tube with heavier nickel plated
parts before exhaust

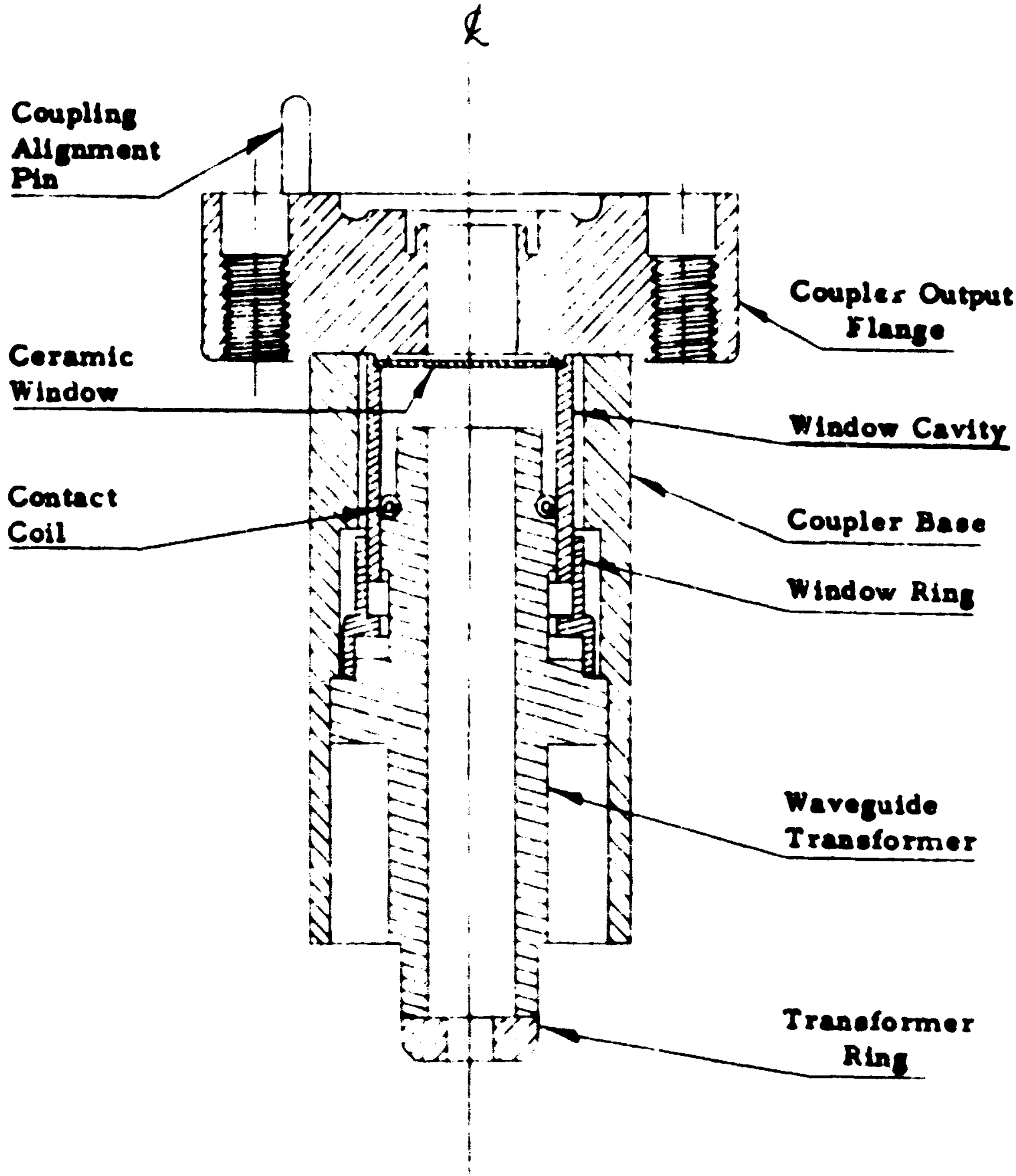
FIGURE 7

III. Ceramic Window

In order to prevent window burnout or suck in during testing or in field service a ceramic output window was substituted for the original glass structure.

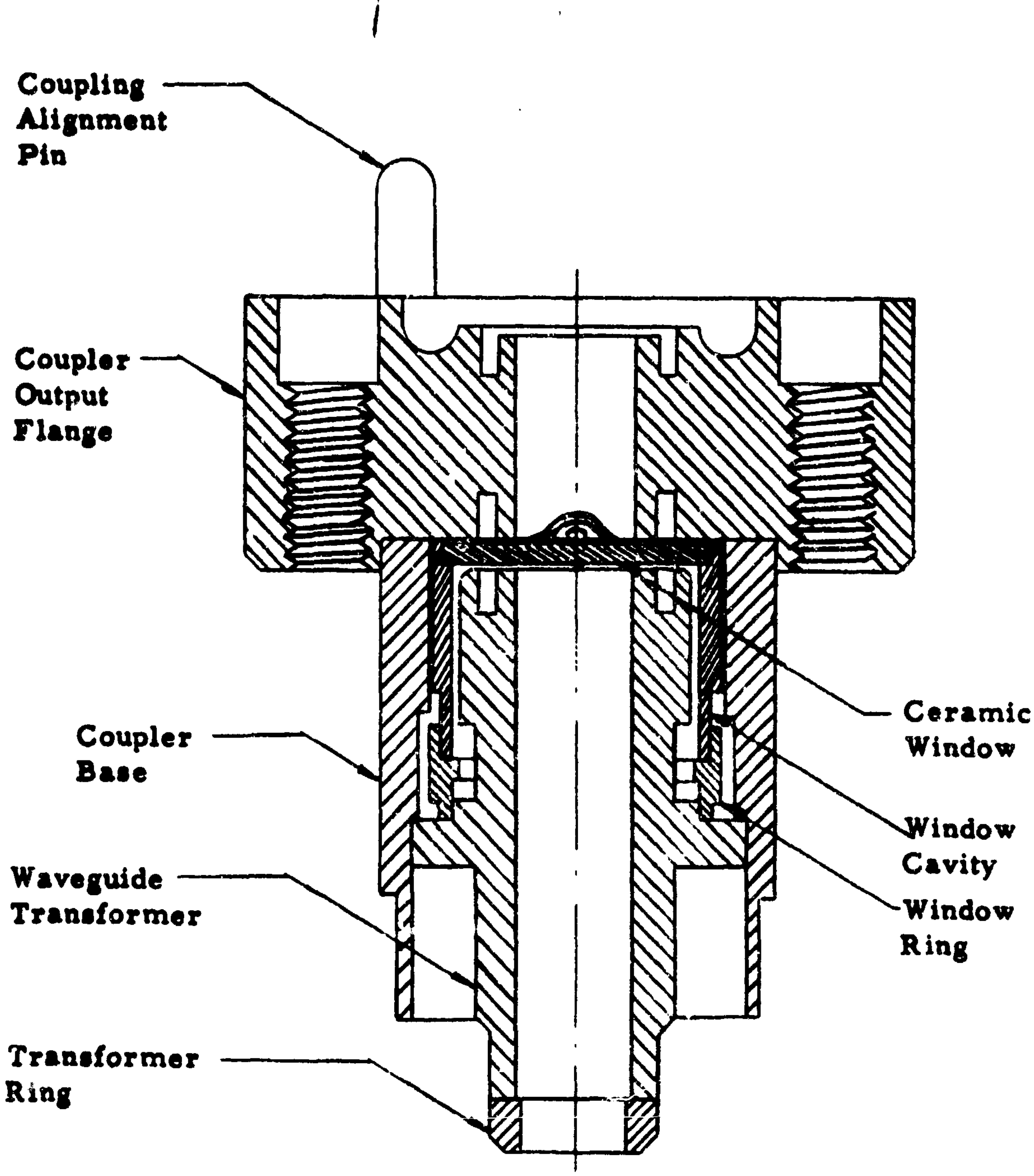
A high Q design shown in Figure 8 was tested and quickly discarded because of the inability to match anode frequency to the window pass band. A broadband design shown in Figure 9 was developed and found satisfactory.

It may be noted by reference to Figure 10 that a low value (1.1 or better) of VSWR was not achieved. The result of this is that output coupler position and exact waterfall configuration critically affect power output at test. An adjustment and/or selection process during first test must therefore be retained.



TENTATIVE	SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY MASSACHUSETTS
	Ceramic Output Window Assembly	3-19-62

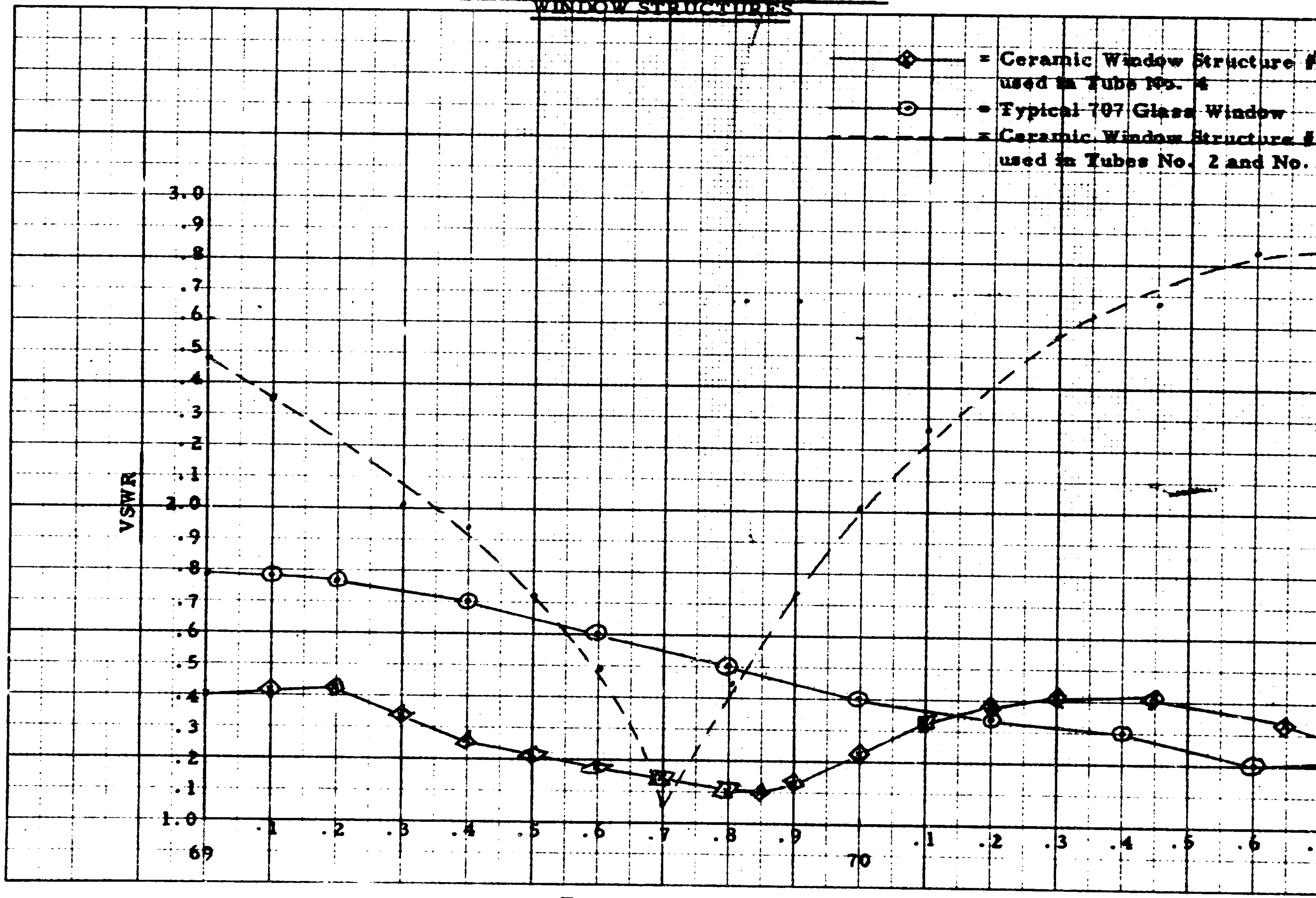
Figure 8



TENTATIVE	SPECIFICATION SHEET Ceramic Output Window Assembly	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
Model No. 2		4/17/62

Figure 9

FREQUENCY vs VOLTAGE STANDING WAVE RATIOS FOR VARIOUS OUTPUT WINDOW STRUCTURES



Frequency in Gc

Figure 10

IV. Anode Manufacture - Bomac Facility

Prior to and during the modification study phase of this program anodes were purchased from Anton Manufacturing Co. These anodes were produced using cold hobbing techniques and were satisfactory in tube manufacture.

Bomac manufacture of anodes commenced during the fifth quarter between 6 August 1962 and 6 November 1962. Ten tubes were made using Hob B-1 which had been made at Columbia to test the hob grinder machine and Hob B-2 which was the first hob ground at Bomac.

The hob material, Vitalium No. L605, as supplied by Austenal Labs of New York City, proved satisfactory. Later it became apparent that the hob material had to be more specifically specified in order to consistently procure material which had adequate hardness. The resulting designation (5" x .800" bars of Varian material, Stellite #34 with hardness of 45 - 50 Rockwell) should be used when procuring this material.

Hob B-1 was found unsatisfactory due to dimensional errors in cavity depth. These tubes moded severely. Hob B-2 was found satisfactory in terms of cavity dimensions but on the initial tube run freqquency scatter was excessive. Later this was determined to be the result of machining and deburring methods. It was necessary to reduce the depth of all cuts during anode machining and make extensive use of the optical comparator to determine dimensional compliance afterwards. The final machine cuts were reduced to .0002" to reduce vane deformation and burring.

IV. Anode Manufacture - Bomac Facility (continued)

The following steps were established for the anode manufacturing routine:

1. Hob blank made from certified Electronic Grade OFHC copper.

2. Blank assembled to hob holding die and thermocouple and placed in hob press.

3. Assembly is heated to 750°C by RF induction heating.

4. Hob is pressed into blank with continuous motion at a constant pressure of 625±25 psi up to a positive stop. This pressure results in a linear speed of penetration of approximately 0.160 in/min.

5. Assembly is cooled and the outer diameter of the anode blank is turned to finished diameter concentric with hob to within .0002" TIR.

6. Anode blank is stripped from hob using Buehler Speed Press at very low pressure.

7. Hobbed blank after preliminary inspection is placed in potting fixture and filled with lucite powder. Potting is heated to 175°C and placed under a pressure of 1000 PSI to fuse the lucite powder.

8. Potted and hobbed blank is then lathe turned to finish diameter dimensions.

9. The lucite potting is washed out with chloroform with the aid of ultrasonic agitation and the machined anode blank is placed in a special spindle tool to allow lathe turning of the output circuit recesses in the side of the block.

10. The anode is deburred by hand and knife methods.

11. Alignment of the blank to center one of the large cavities on the spindle axes is done on the optical comparator.

12. The anode must now be repotted with lucite in the same manner as in Step 7 to prevent collapse of the vane structure during output machining.

IV. Anode Manufacture - Bomac Facility (continued)

13. The output recesses are lathe turned into the anode.

14. The potting is again dissolved in chloroform as in Step 9.

15. The output area is deburred.

16. The machined anode is then measured on the optical comparator. All dimensions are recorded for Engineering study and acceptance.

Life of accepted hobs with this procedure is at least 50 anodes. An attempt was made to cold hob but life of all cold hobs made at Bomac was limited to only 4 or 5 presses.

The disadvantages of the above procedures are:

1. The two potting operations consume excessive time. To accomplish the rate goal an improved potting method should be tried. If such cannot be found then the rate can be achieved by duplication of facility. The potting material to be tried sometime in the future consists of a mix of precipitated calcium carbonate, ERL-2795 plastic from Palmer Products and hardener ERL-2743.

2. Hot hobbing results in annealed units having substantial burrs. Hand deburring, which requires high skill, is the only method of deburring that produced acceptable results.

3. Dimensional requirements are so severe that even the most skilled machinist working with a precision lathe can only turn out about a 50% acceptance rate. To reach the rate goal at acceptable costs, special machines which are available, should be used. However, duplication of present lathe equipment would achieve the rate goal if necessary.

Spark machining methods were investigated to machine the output recesses. The cutting speeds were set to improve upon the time required to lathe turn these dimensions. Dimensional and burring results were worse. It was concluded that spark machining would work as an alternate method but that unit cost would not be improved.

IV. Anode Manufacture - Bomac Facility (continued)

Another hob, B-3, was made to back up hob number B-2 in preparation of the pilot run. Hob B-2 and B-3 were used to make the pre-production samples.

Figures 11 and 12 show the hobbing and machining tools for these operations.

ANODE FABRICATION TOOLS

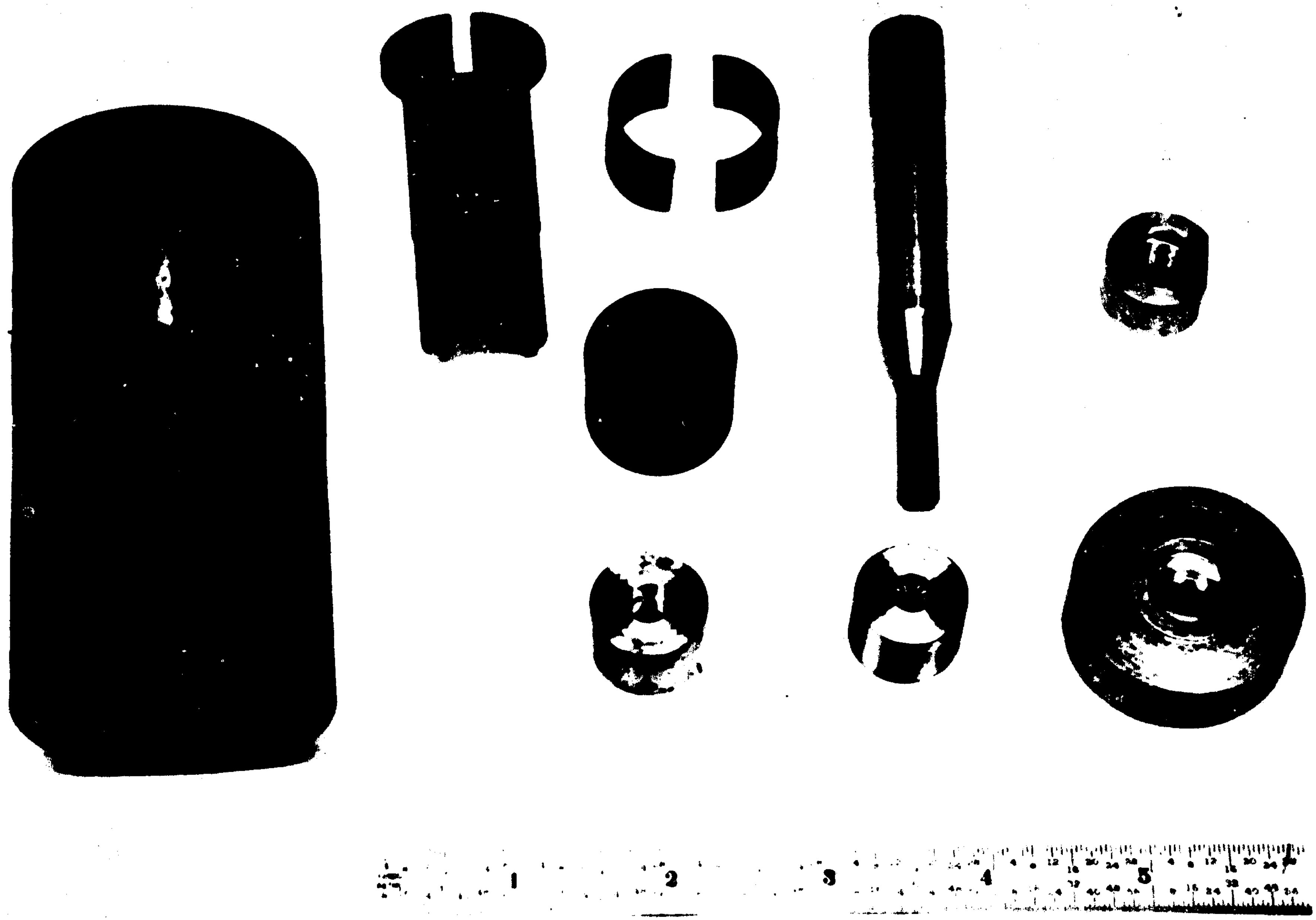


FIGURE 11

ANODE SHOP EQUIPMENT

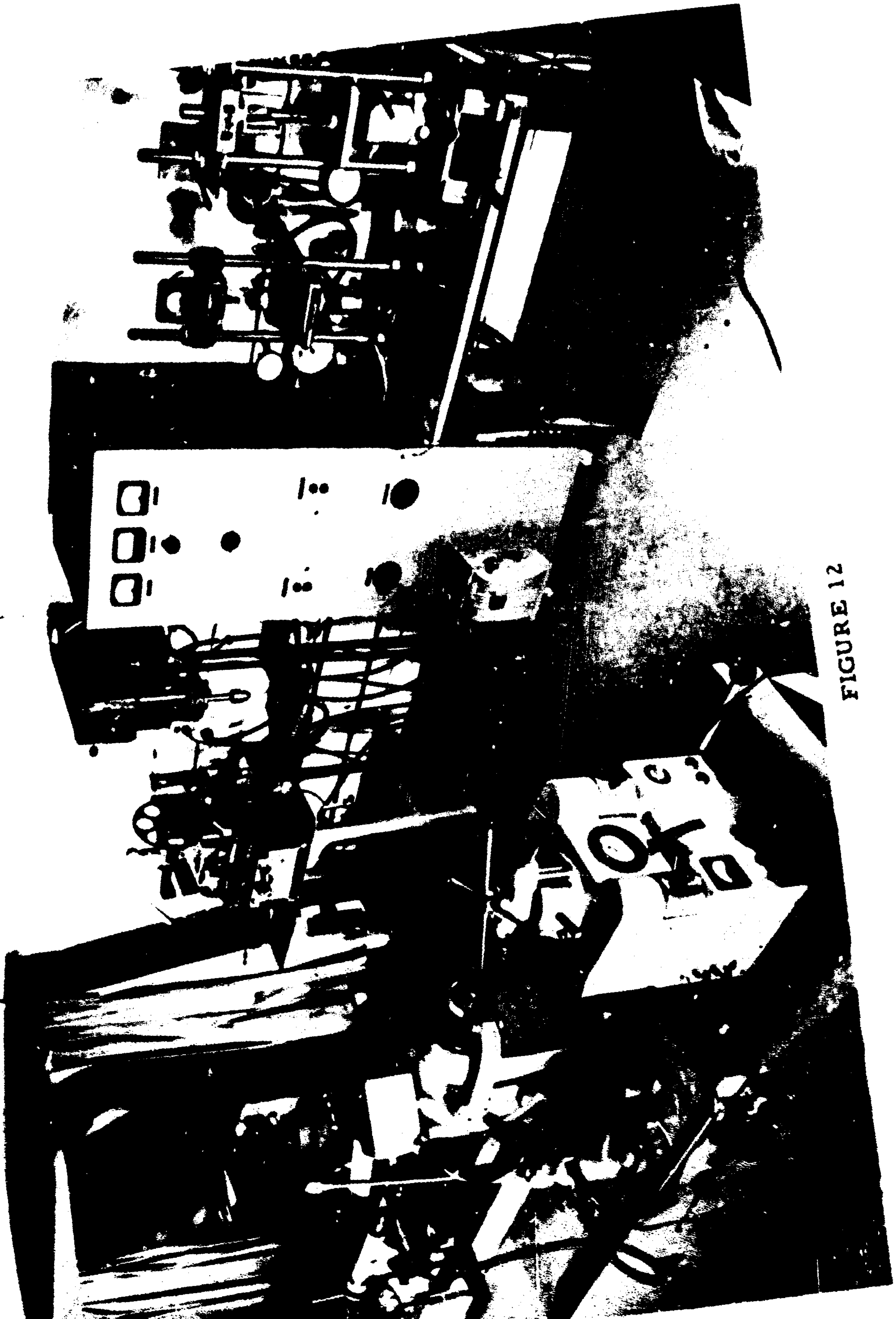


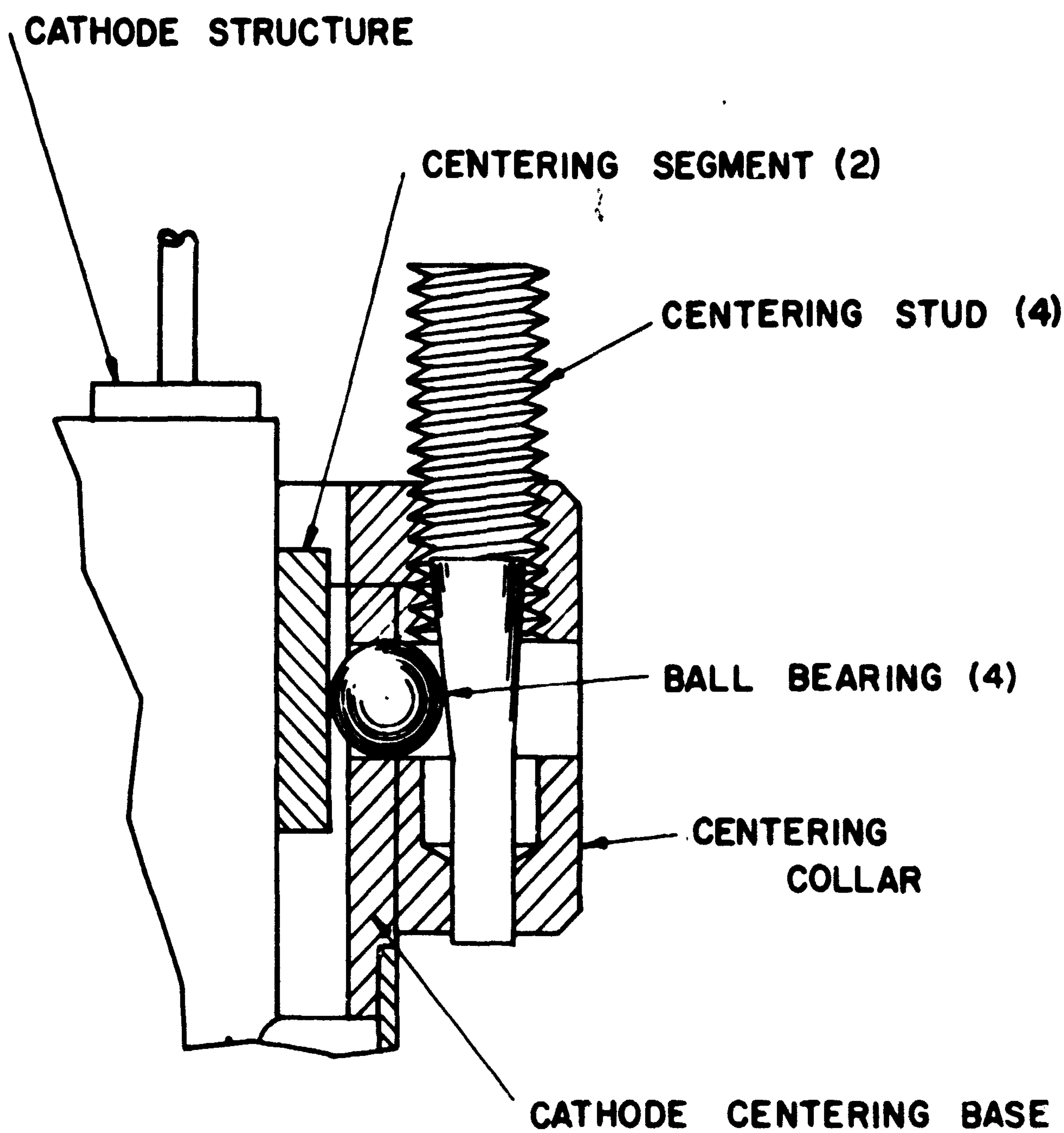
FIGURE 12

V. Manufacturing Methods Improvement

A. Cathode Centering Device

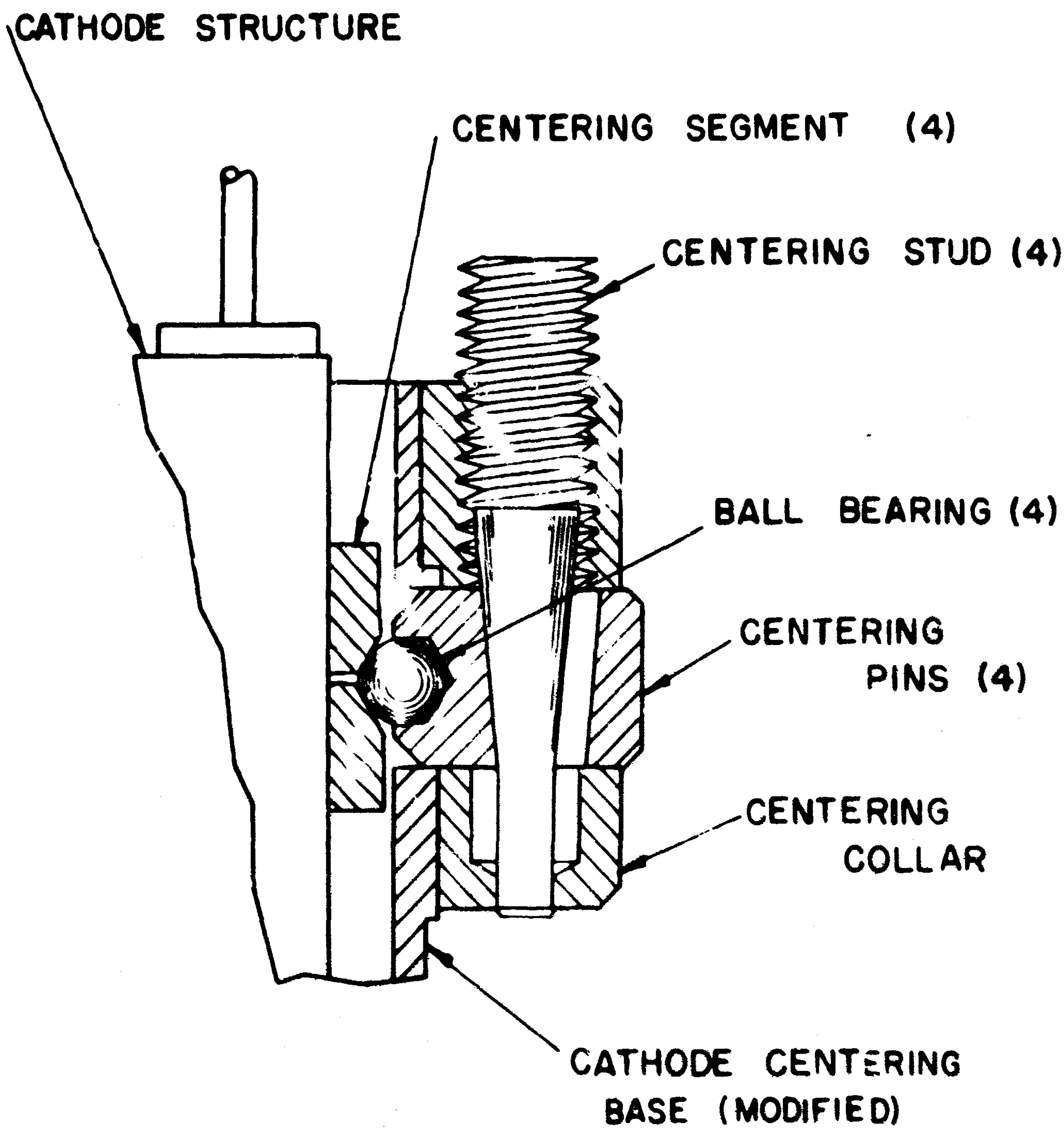
The BL-221 contains a cathode centering assembly permanently affixed to the magnetron. Radial centering changes of less than .002" will change a tube from complete acceptability to complete mode behavior. Because of this, the device must be smooth in its operation and stable in storage. The original design, shown in Figure 13, used 4 centering studs pushing on 4 ball bearings on point contacts and these in turn pushed on 2 centering segments. In use the centering studs became scribed and the adjustment became discontinuous. Further, 2 centering studs could not uniquely conform to the diameter of the cathode structure and hence a small amount of backlash existed between the centering segments and the cathode. The new structure, as can be seen in Figure 14, corrects both of these defects.

The centering segments, ball bearings, and centering pins are all hard materials and have exhibited essentially zero plastic flow during the tube life. Thus the position achieved during testing should be stable for an adequate amount of time.



	SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
	(OLD)	
	CATHODE CENTERING ASSEMBLY	10/18/62

FIGURE 13



SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
(NEW) CATHODE CENTERING ASSEMBLY	10/18/62

FIGURE 14

V. Manufacturing Methods Improvement (continued)

B. Frequency Tuning

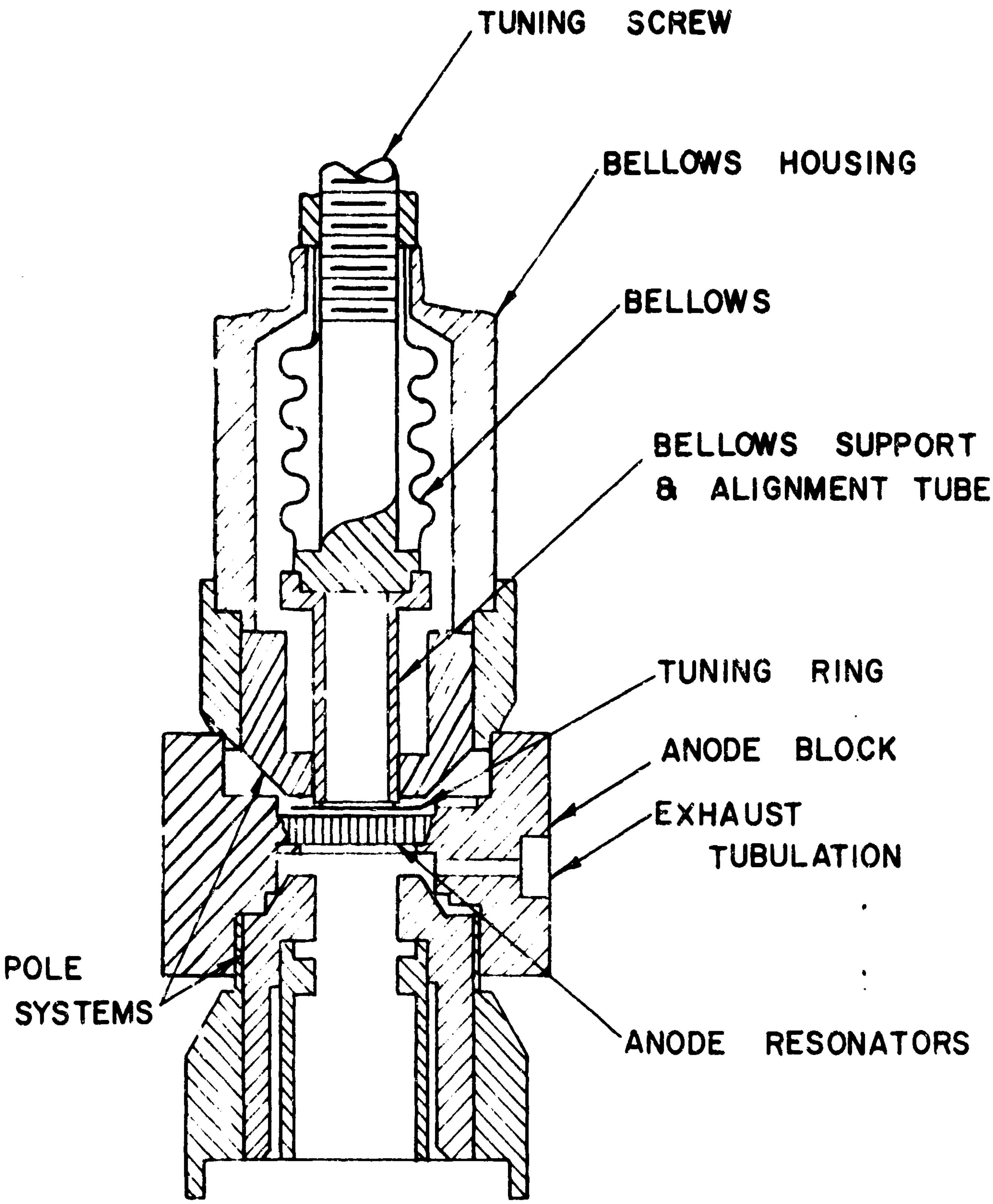
In order to reduce the dimensional severity of the anode machining operation it was thought that a frequency adjuster could be included in the tube design to bring tubes at test to the correct frequency when these tubes were built with anodes which were off frequency at the start.

With the second design, as shown in Figure 15, a tuning adjustment of 2.5 Gc was achieved. This amount is adequate to appreciably relieve the dimensional tolerances required of the anode machining operation. However, mode stability changes and power output variations with frequency changes severely limited the amount of tuning actually achieved in finished tubes. The effort was discontinued.

C. Cold Test

All of the resonance and Q measurements made on this device have been done using a QK 865 klystron as a power source and slotted line point by point plotting methods.

Near the end of the program a Varian Canada klystron VC-705 was procured to provide sufficient power to operate a reflectometer type of cold test bench. It is quite apparent at this time that production observations of resonance characteristics of the π and π-1 modes and the determination of cold resonance frequency has been aided.



SPECIFICATION SHEET

TUNER MODEL NO. 2

BOMAC LABORATORIES INC.
SALEM ROAD
BEVERLY, MASSACHUSETTS

FIGURE 15

V. Manufacturing Methods Improvement

C. Cold Test (continued)

More work is required, however, to establish better correlation between cold test and hot test results.

A wide band sweeper can now be assembled at this band and such should be done prior to any new development or major production work.

D. Processing of Bomac Manufactured Anodes

During the first attempt to evaluate tubes made with Bomac manufactured anodes in preparation for the submission of pre-production samples it was found that operational life was very poor. The tubes exhibited rapid deterioration of cathode emission. On dissection anode vane tips were found severely erroded, copper deposition on the cathode emitter was evident and carbon particles were found.

Procedures for cleaning and processing the anode part was investigated. It was found that simple soaking in chloroform was insufficient to achieve adequate removal of the lucite potting material. Ultrasonic agitation was added to the anode manufacturing procedure.

In addition, it was decided that additional processing would be desirable to insure complete removal of all organic materials and rough edges from the hand deburring operation.

V. Manufacturing Methods Improvement

D. (continued)

The resulting process is as follows:

1) Following ultrasonic cleaning in chloroform and adequate water rinsing the anode and output structure is brazed in very wet hydrogen to remove carbon.

2) The assembly is electrolytically polished in the area of the anode vane tips.

3) The assembly is ultrasonically washed to remove all traces of glycerine which is used in the electropolish solution.

4) An oxidizing, etching, and hydrogen firing sequence was tried at this point but later discarded as not necessary.

5) The assembly is vacuum fired and inspected for discolorations and deposits and if clean is allowed to proceed to the next assembly.

Considering the poor life noted on the first tubes manufactured with Bomac anodes it was believed necessary to re-evaluate the entire design after the introduction of the above processing for shelf and operational life prior to any attempt to submit for pre-production approval. Such was done and the life results were so much improved that a specification change adding 50% to the cycle life test was proposed.

V. Manufacturing Methods Improvement (continued)

E. Test Specification

The introduction of the improved anode cleaning process and new more accurate methods of test kit calibration added one new problem. The tubes were high in peak anode voltage to the 14.2 kv maximum test limit.

About 500 volts were added to the test readings due to correction in the voltage calibration methods. About 300 volts were added to the actual voltage because of anode diameter increase during electropolishing. A review of data also indicated that the tubes with lower values of anode voltage also had greater leakage current and hence were less efficient.

Two things were done to correct the problem. First a change from 14.2 kv to 14.6 kv maximum and 15.0 kv maximum at end of life was negotiated with Signal Corps technical personnel. Secondly, the machined dimension of the anode inner diameter was reduced by .0005" to compensate for the electropolishing.

In parallel a new hob was made to voltage scaled dimensions. Tubes made with these voltage scaled anodes however, were mode unstable. This approach was dropped when the above solution was proven.

A revised specification was agreed to on 23 October 1963 and the tube was registered as an 8558 with reference to that specification.

VI. Test Equipment and Measurements

Three test stations were built to be added to test stations built on previous contracts. Also a spectrum analyzer was constructed.

The contract specification called for an oscillation condition using a 0.03 μsec pulse width and a duty cycle of .0005 in addition to two other sets of conditions. The high repetition frequency involved with this particular oscillation condition caused overheating of the high voltage power supply plate transformer and the charging choke parts of the two soft tube type of modulators.

Although considerable effort was expended to obtain parts with sufficient rating this condition had to be reduced to a lower duty cycle before testing could be accomplished at the short pulse. The specification now in issue reflects this change.

The total test line now includes two soft tube modulators, two hard tube modulators and two life test or aging modulators. All sets have adequate plumbing and their are two spectrum analyzers. This is sufficient to achieve the monthly rate goal.

PREPRODUCTION APPROVAL TESTS AND PROCEDURES

I. Introduction

1.1 The governing specification for this testing, entitled BL-221, and hereafter referred to as the TSS (Tube Specification Sheet), is dated 9-23-63. A copy of this specification approved by the Signal Corps on 10-23-63, will be found in Appendix I. Application for RETMA registration was made after the specification approval and the tube type number 8558 was subsequently assigned.

1.2 The order of testing and test dates were as follows:

	Test	Date
1.2.1	Cycling Life Test (start)	11-18-63
1.2.2	Pressure Tests and Initial Electrical Tests	12- 5-63
1.2.3	Vibration Tests and Post Vibration Electrical Tests	12-10-63
1.2.4	Shock Tests and Post Shock Electrical Tests	12-11-63
1.2.5	Temperature Tests	12-11-63
1.2.6	Pre Shelf Electrical Tests	12-18-63
1.2.7	Final Electrical Tests	3-19-64
1.2.8	Dimensions	3-20-64

1.3 Testing was performed at Varian Associates, Bomac Division, Beverly, Massachusetts.

1.4 Technical Personnel

1.4.1 Thomas G. Prescott

Mr. Prescott received the Bachelor of Science Degree in Electrical Engineering from the State University of Iowa in 1943. Mr. Prescott was employed by Sylvania Electrical Products, Inc. from 1944 to 1948 as a Project Engineer on developmental magnetrons. He served as Technical Radar Officer in the U.S. Navy from 1944 to 1946.

Joining Bomac Laboratories Inc., in 1948, Mr. Prescott served as Senior Engineer in magnetron development and assumed the duties of Chief Factory Engineer in 1951. Since 1958 he has been responsible for all phases of Quality Control and Reliability for the Bomac Division of Varian Associates, successor to Bomac Laboratories, Inc.

1. Introduction

1.4 Technical Personnel

1.4.1 Thomas G. Prescott (continued)

Mr. Prescott is a patentee in the Microwave Devices field. He is a member of the American Society for Quality Control and is a Registered Professional Engineer in Massachusetts.

1.4.2 William G. Richards

Mr. Richards graduated from high school in 1945 and studied at the School of Practical Arts and Northeastern University in Boston, Mass. from 1948 through 1951.

In 1952 he joined CBS Electronics where he supervised and directed the sampling and testing for acceptance of all production. He maintained close liaison with the Signal Corps and applied the principles of Quality Control to all products. He then joined Varian Associates, Bomac Division as Foreman of Quality Control in the Power Tube Group. In that capacity he supervises and sets up in-process inspection of all processes and establishes electrical sampling per military and commercial specifications on magnetrons and klystrons.

1.4.3 John J. Boyson

Mr. Boyson, after graduation from high school in 1948, entered the Air Force. He received a diploma from the ATC Radar School, Kessler AFB, Mississippi in 1949. He then received experience in the operation, maintenance and supervision of several radio and radar equipments at installations in Texas, Okinawa, Japan, and Maine. Upon leaving the service, John joined Bomac Laboratories as a Test Operator. He gained a years experience in the testing of UHF triodes, and in 1954 he was assigned to the Magnetron Development Section as a Test Operator. During the past ten years he has performed evaluation tests on developmental magnetrons at frequencies from 5 Gc to 70 Gc. During this period he assisted in the construction of the BL-201 magnetron, forerunner of the BL-221, and has had nearly continual contact with the testing of the latter tube. He is presently responsible for the special testing and

1. Introduction

1.4 Technical Personnel

1.4.3 John J. Boyson (continued)

pulse circuit work associated with the customer applications of magnetrons. John has attended both the Northeastern University Evening Division (1955-1957) and Merrimac College Evening Division (1961 - 1962) where he took pertinent courses.

1.4.4 Norman F. Tremblay

Mr. Tremblay graduated from high school in 1956. He joined Bomac Laboratories in 1957 as a worker in the Production Department where he gained general experience in the construction and finishing of TR and ATR tubes. In 1959 he received initial training in the low and high level testing of TR and ATR's. He continued, now in Production Engineering, receiving further test experience until 1962, when he was transferred to the Power Tube Product Development Group. In that group, initially he maintained and constructed magnetron test plumbing components. During the past year his duties have included the testing and evaluation of developmental magnetrons from "C" band through "V" band.

1.4.5 Michael Geras

Mr. Geras graduated from high school in 1953. He held a rating of EM2 in the United States Navy from 1953 to 1957. Michael attended Service School "Electrical Class A" in 1954, Massachusetts Radio School for Radio Technicians from 1960 to 1962 and the Massachusetts Radio School for Electronic Technicians from 1962 to the present time. Mr. Geras was hired at Bomac on March 26, 1957 as a production assembler. He has been employed here at Bomac as a Test Technician for the past five years.

1. Introduction

1.4 Technical Personnel (continued)

1.4.6 Richard Flynn

Mr. Flynn graduated from high school in 1955, and attended Service School "Radar Class A and B" in 1960, he has been attending Lincoln College (Northeastern University) evening school since 1962 for Assoc. in Engineering. Mr. Flynn is at the present time in the U. S. Naval Reserve. He was hired at Bomac on January 8, 1956 and worked for two and a half years as a production assembler, three and one half years as a Test Technican, and for the past two years he has been employed here at Bomac as an Environmental Technician.

1.5 Standard Equipment Used Included:

	Manufacturer	Model	Serial No.	Calibration Date	Accuracy
1.5.1	Tektronix scope with L head plug in unit	541A	020896	12-11-63	3%
1.5.2	Associated Testing Labs High-low temperature chamber	SLHU-1-LC-1	2021		
1.5.3	All American Mechanical Vibrator	25HA	9931	9-24-63	±1 CPS
1.5.4	Taft-Pierce Shock Machine (Naval Shock Machine)	JAN-180		3-18-63	2%
1.5.5	Browning Labs Standing Wave Ratio Amplifier	TAA-16B	249		
1.5.6	FXR Directional Coupler	M610D	130		.4 db

1. Introduction

1.5 Standard Equipment Used Included: (continued)

	Manufacturer	Model	Serial No.	Calibration Date	Accuracy
1.5.7	Microwave Assoc. High Power Dry Load (2)	MA-721			
1.5.8	Microwave Assoc. Standard Gain Antenna (2)	MA-627	54 and 57		

1.6 Non Standard Equipment Used:

1.6.1 Modulator in Console, Hard Tube

This modulator, was built by Bomac under Contract DA-36-039-SC-73285. This unit is used for all the routine electrical testing of the magnetron and is shown in Figure 16. The test position and plumbing is shown in Figure 17. The modulator supplies the following pulse conditions:

Pulse Voltage = 0 - 15 kv
Pulse Current = 10 Amperes Peak
Duty Cycle = .0005 max.
Pulse Width = .03, .07 and .25 μs nominal
Repetition Rate = 500 min. to 12,000 pps max.
Calibration Date: 12-4-63

1.6.2 Modulator in Console, Soft Tube, Line Type

This modulator was also built by Bomac under Contract DA-36-039-SC-73285. Used normally for aging the tubes, it was used during the preproduction testing for pulsing the magnetron during the Temperature Coefficient and Low Temperature measurements. It is shown in Figure 18. The modulator supplies the following pulse conditions:

Pulse Voltage = 0 - 15 kv
Pulse Current = 10 Amperes Peak
Duty Cycle = .0005
Pulse Width = .07 μs nominal
Repetition Rate = 7150 pps
Calibration Date: 12-2-63

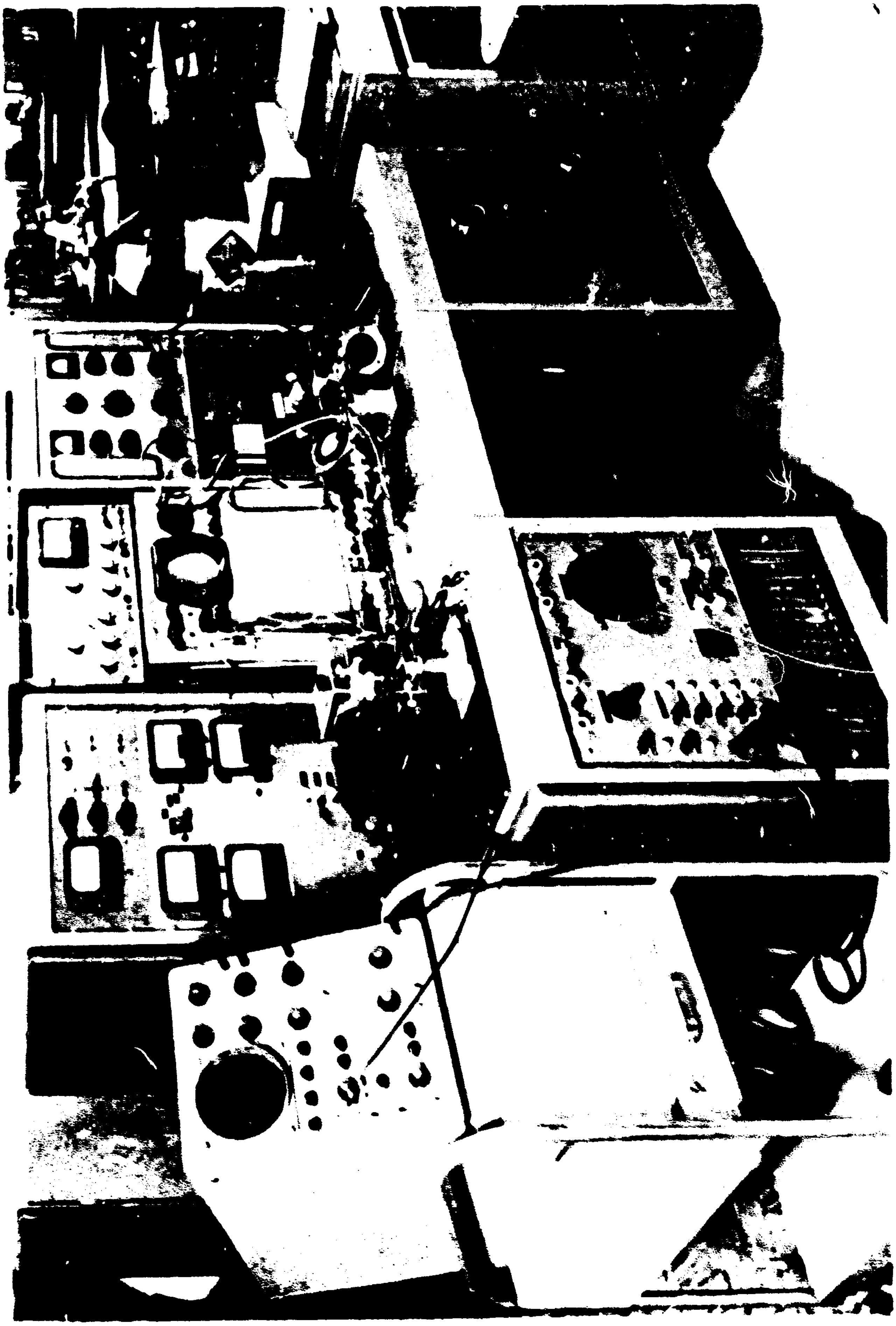


FIGURE 16

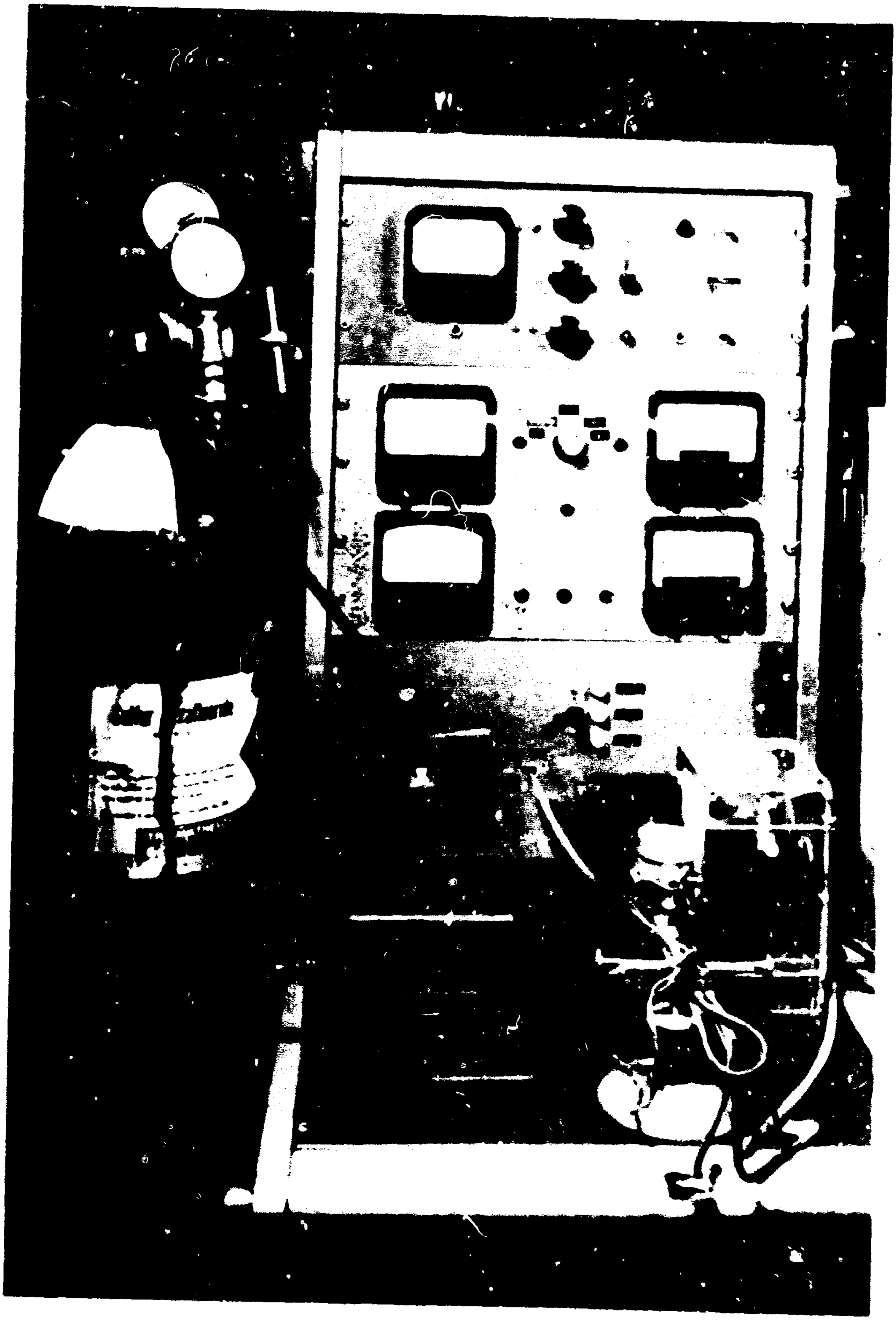


FIGURE 17

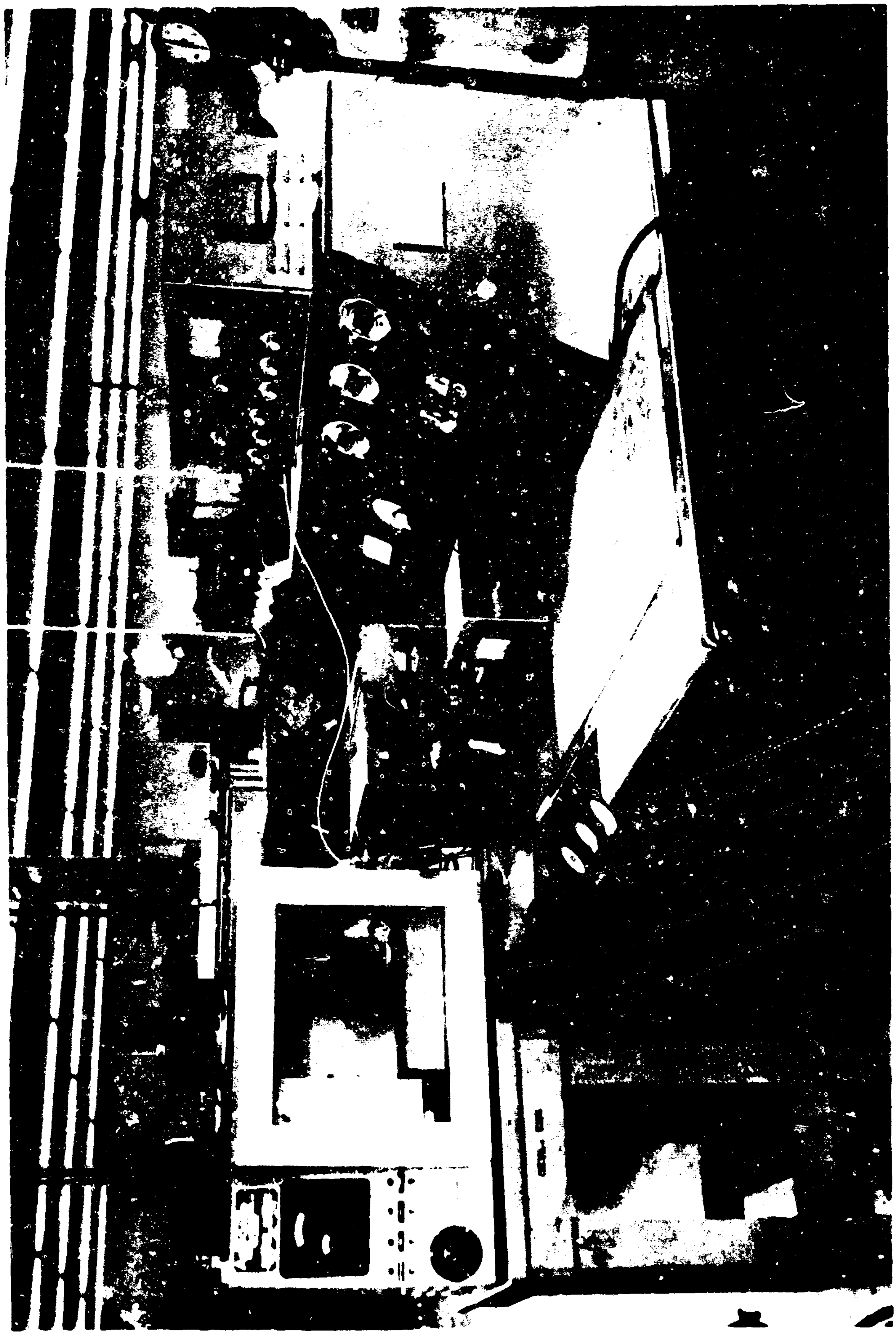


FIGURE 18

1. Introduction

1.6 Non Standard Equipment Used: (continued)

1.6.3 Modulator in Console, Soft Tube, Line Type

This modulator was also built by Bomac. It however, was built under the existing PEM Contract DA-36-039-SC-85974. It was used during Life Testing of Tube No. 73 and is shown in Figure 19. This modulator supplies the following pulse conditions:

Pulse Voltage = 0 - 15 kv
Pulse Current = 10 Amperes Peak
Duty Cycle = .0005
Pulse Width = .07 μs nominal
Repetition Rate = 7150 pps
Calibration Date: 11-7-63

1.6.4 Modulator, Portable, Soft Tube, Line Type

This modulator is of Bomac construction, having been built under Contract DA-36-039-SC-73285. It was used for tests during shock and vibration and is shown in Figure 20. It supplies the following pulse conditions:

Pulse Voltage = 0 - 15 kv
Pulse Current = 10 Amperes Peak
Duty Cycle = .0005 max.
Pulse Width = .07 μs
Repetition Rate = 7150 pps
Calibration Date : 12-10-63

1.6.5 Waterload and Pulling Machine

This device has been adequately described on Pages 39 and 42 of the Final Engineering Report - BL-221, Volume I prepared under Contract No. DA-36-039-SC-73285. It is shown in Figure 21. The unit is used during the measurement of RF Bandwidth, Minor Lobes, Pulling Factor, and Stability. It was last calibrated on 12-4-63.

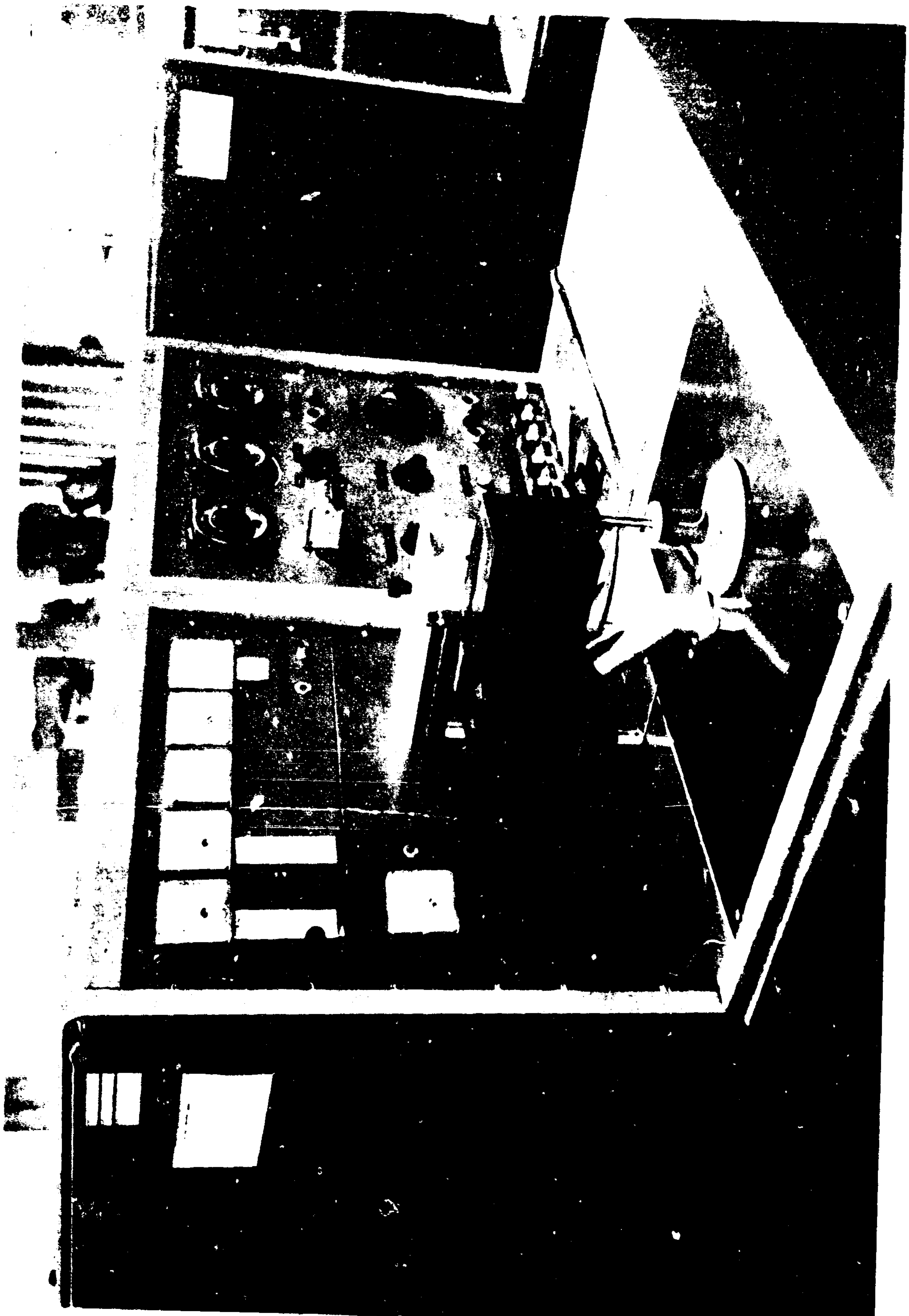


FIGURE 19

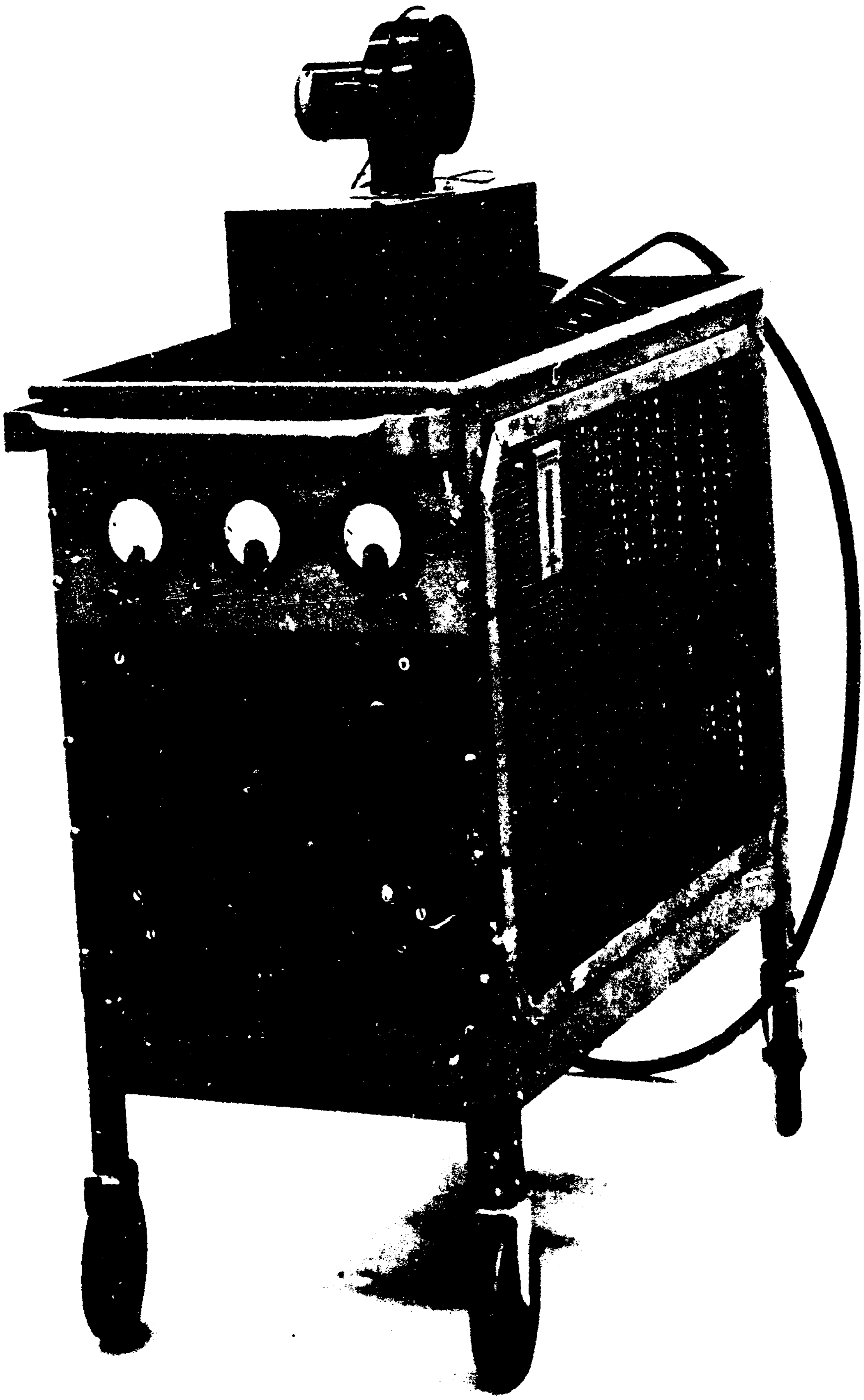


FIGURE 20

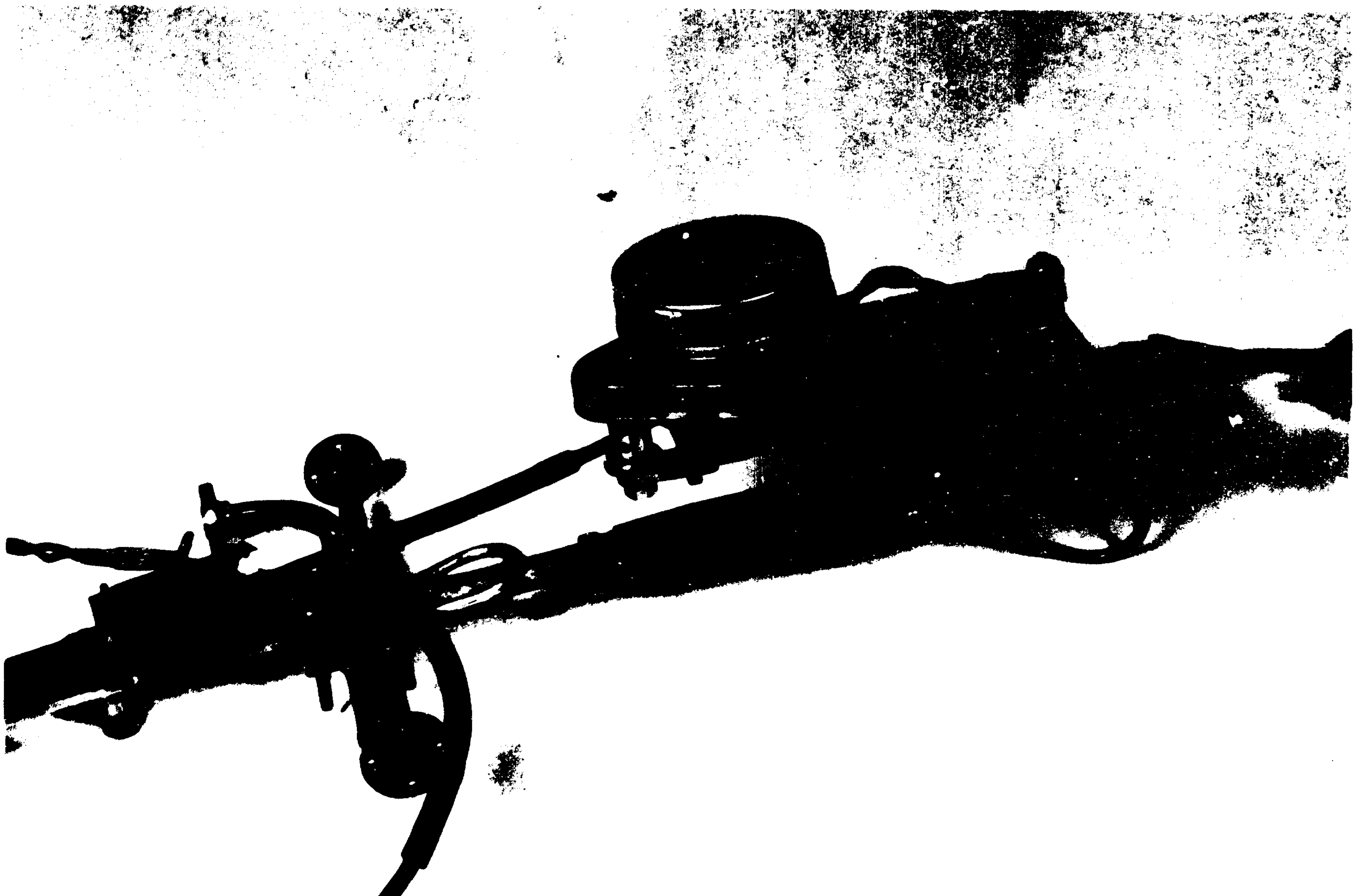


FIGURE 21

1. Introduction

1.6 Non Standard Equipment Used: (continued)

1.6.6 Spectrum Analysis Equipment

Spectrum investigation is accomplished by use of a Bomac designed and assembled 70 Gc spectrum analyzer. The analyzer was originally constructed under Contract DA-36-039-SC-73285. It has been modified to use the new crystal mount and diode. It was adequately described on Pages 42, 45, 46, and 47 of the Final Engineering Report, BL-221, Volume I, prepared under Contract No. DA-36-039-SC-73285. The analyzer is used during the measurement of R.F. Bandwidth, Minor Lobes, Pulling Factor, Stability, * Stability and ** Stability.

2. Holding Period

2.1 Requirements

2.1.1 The requirements of Paragraph 4.5 of MIL-E-1D apply. This paragraph states that tests marked with a dagger sign may be made before and shall be made at the conclusion of the holding period; and tests not marked may be made before or after the holding period.

2.1.2 No tests are marked with a dagger sign in the TSS.

2.2 Procedure

2.2.1 Hold the tubes for the specified period of 168 hours after completion of manufacturing processes, and then subject them to the tests described in the following sections.

2.3 Test Equipment

2.3.1 None was required.

2.4 Test Results

2.4.1 No problems were encountered.

3. Dimensions

3.1 Requirements

3.1.1 Paragraph 4.9.2 of MIL-E-1D states, "Each tube shall be inspected for conformance as to size, shape, and finish according to the applicable drawing specified on the tube specification sheet. The dimensions, except those for cathode-ray tubes, shall be checked on a qualification design, or production test basis as specified on the tube specification sheet or on the outline drawing".

3.2 Procedure

3.2.1 Measure the tubes and compare with the outline drawing. They shall satisfy all requirements of the outline drawing.

3. Dimensions (continued)

3.3 Test Equipment

3.3.1 Test equipment consists of various tools, such as micrometer, micrometer caliper, vernier height gauge and similar devices usually used in a well organized and equipped Quality Control Department.

3.4 Test Results

3.4.1 Tubes were measured and found to correspond to outline drawings, Figures 1, 2, 3 and 4 (dated 12-20-60) of the TSS.

4. Shock

4.1 Requirements

4.1.1 No MIL-E-1D reference is made in the TSS for this test.

4.1.2 The conditions given in the TSS are as follows:

No Voltage: 50G; 4 Ms duration.

4.2 Procedure

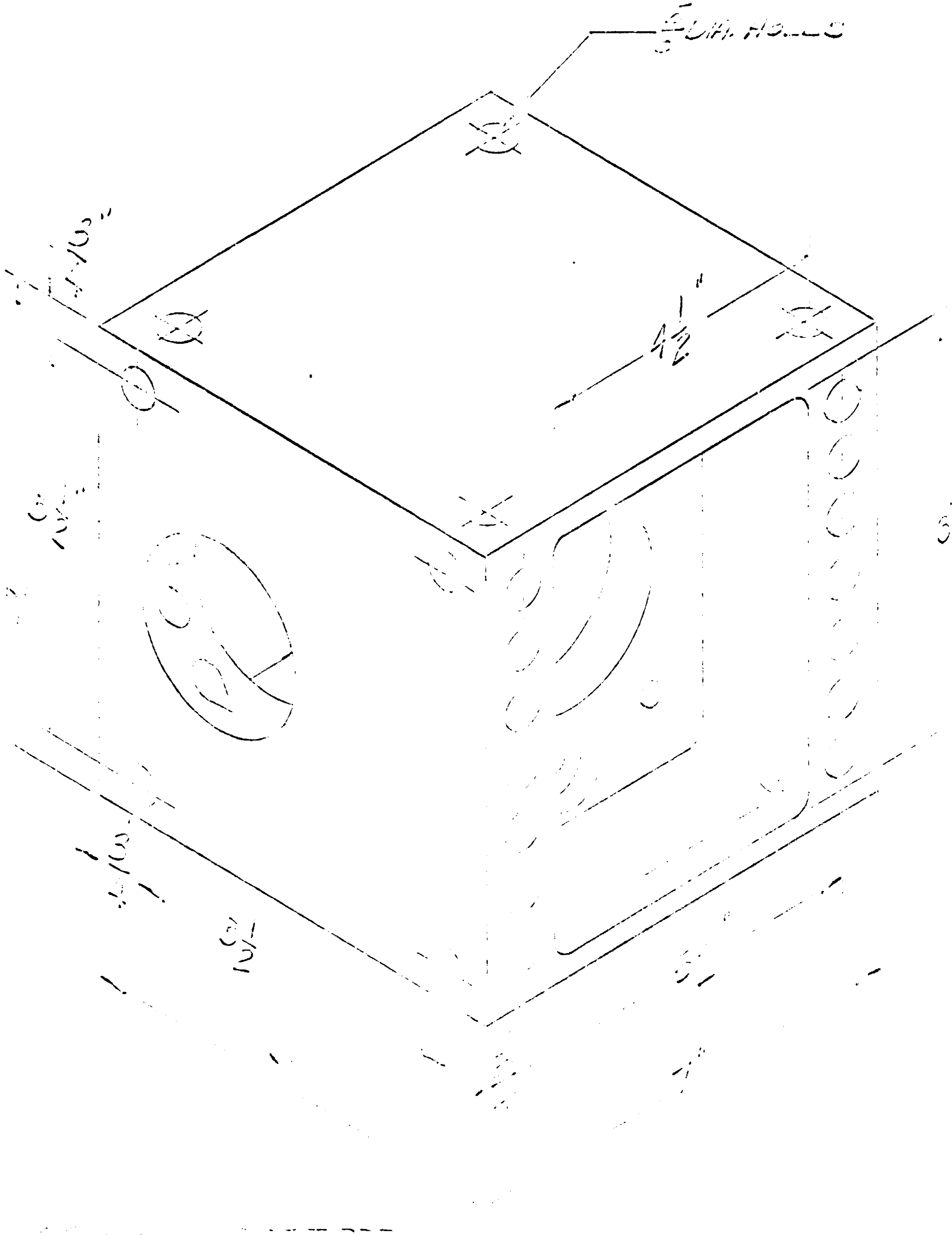
4.2.1 Make initial tests on all tubes under Oscillation (1), (2), and (3) conditions, following procedure outlined in Paragraphs 11.0 and 12.0 and 13.0 which are found on pages 61 through 64 of this report. Record data. (This data is found in the Data Section which begins on page 72).

4.2.2 Bolt the test jig shown in Figure 22 to the table of a JAN-180 shock machine using a 1-9/16" thick brass spacer between the jig and the table.

4.2.3 Interpose a resilient cushion between the hammer and anvil of the table.

4.2.4 Select a suitable hammer angle to produce a shock of the specified magnitude and duration.

4.2.5 Bolt the tube to be tested to the test jig so that the shock will be applied parallel to the cathode, with the cathode terminals pointing away from the hammer.



4. Shock

4.2 Procedure (continued)

4.2.6 Apply one shock

4.2.7 Repeat 4.2.5 and 4.2.6 so that the shock will be applied perpendicular to the cathode axis and waveguide axis.

4.2.8 Repeat 4.2.5 and 4.2.6 so that the shock will be applied perpendicular to the cathode axis and parallel to the output waveguide axis.

4.2.9 Make post-shock tests as outlined in Paragraphs 11.0, 12.0 and 13.0 which follow.

4.3 Description of Test Equipment

4.3.1 A photograph showing the shock machine with magnetron in place on the test jig is shown in Figure 23.

4.4 Test Results

4.4.1 The tubes showed no mechanical failure and met all electrical requirements of the TSS except life test, which is not a criterion for passing this test. Electrical parameters before and after shock test are shown on the Qualification Test Data Sheets in the Data Section.

5. High Frequency Vibration

5.1 Requirements

5.1.1 Note 15 of the TSS sheet states: "Vibration frequency will vary from 10 to 50 to 10 cps at a displacement of ±.04" (or .08" peak to peak) at a uniform rate in not less than ten minutes. The test will be performed along each of three mutually perpendicular axes."

5.1.2 The conditions of the TSS are as follows:

$$\text{Osc. 2, BW} = \frac{3.0}{tp} \quad \text{MC}$$

5.2 Procedure

5.2.1 Bolt the test jig shown in Figure 22 to the table of the vibrator.

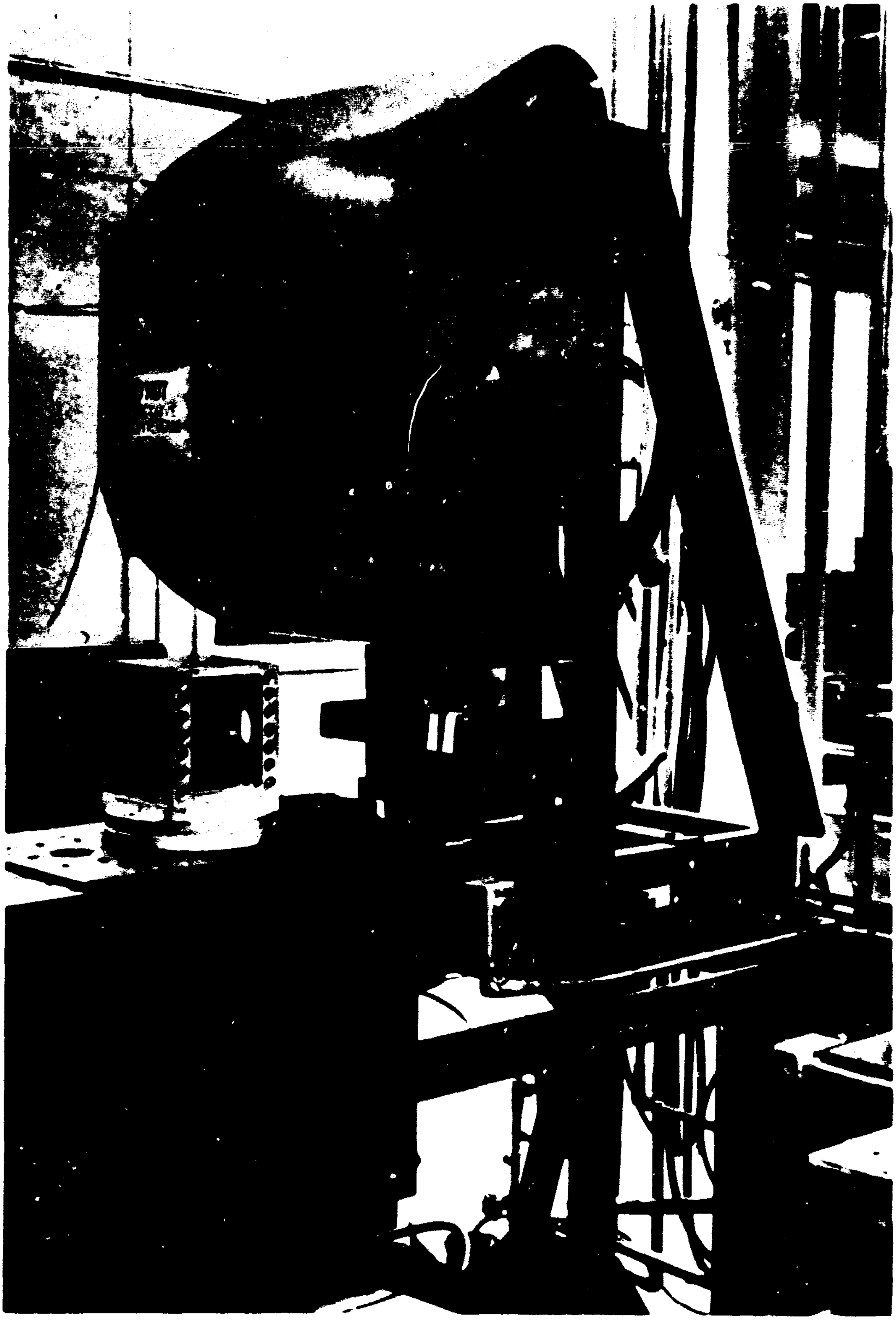


FIGURE 23

5. High Frequency Vibration

5.2 Procedure (continued)

5.2.2 Mount the tube on the jig in such a position that vibration will be along the X_1 axis.

5.2.3 Connect the portable modulator, shown in Figure 20 to the tube and preheat for 90 seconds.

5.2.4 Apply pulse voltage and operate tube under Oscillation 2 conditions as outlined under Test Procedure Paragraph 12.0 with a waveguide horn as a load.

5.2.5 Detect the R.F. energy with the spectrum analyzer with another waveguide horn as a pick up device.

5.2.6 Monitor the spectrum, and measure and record the bandwidth during vibration with the assistance of the marker pip of the analyzer.

5.2.7 Repeat 5.2.2 through 5.2.6 with vibration applied along the Y axis.

5.2.8 Repeat 5.2.2 through 5.2.6 with vibration applied along the X_2 axis.

5.2.9 Make pre-shelf tests as outlined in Paragraphs 11.0, 12.0 and 13.0 which follow.

5.3 Description of Test Equipment

5.3.1 The portable modulator is to be used in this test.

5.3.2 All American Vibrator is to be used.

5.3.3 The vibration test jig, shown in Figure 22, is to be used.

5.3.4 Spectrum Analyzer is to be used.

5.3.5 A photograph showing the vibration machine, test jig, magnetron in jig, and bandwidth measuring equipment is shown in Figure 24.

5.3.6 A photograph showing the magnetron in jig with transmitting horn and receiving horn plus Bomac Spectrum Analyzer R.F. head is shown in Figure 25.

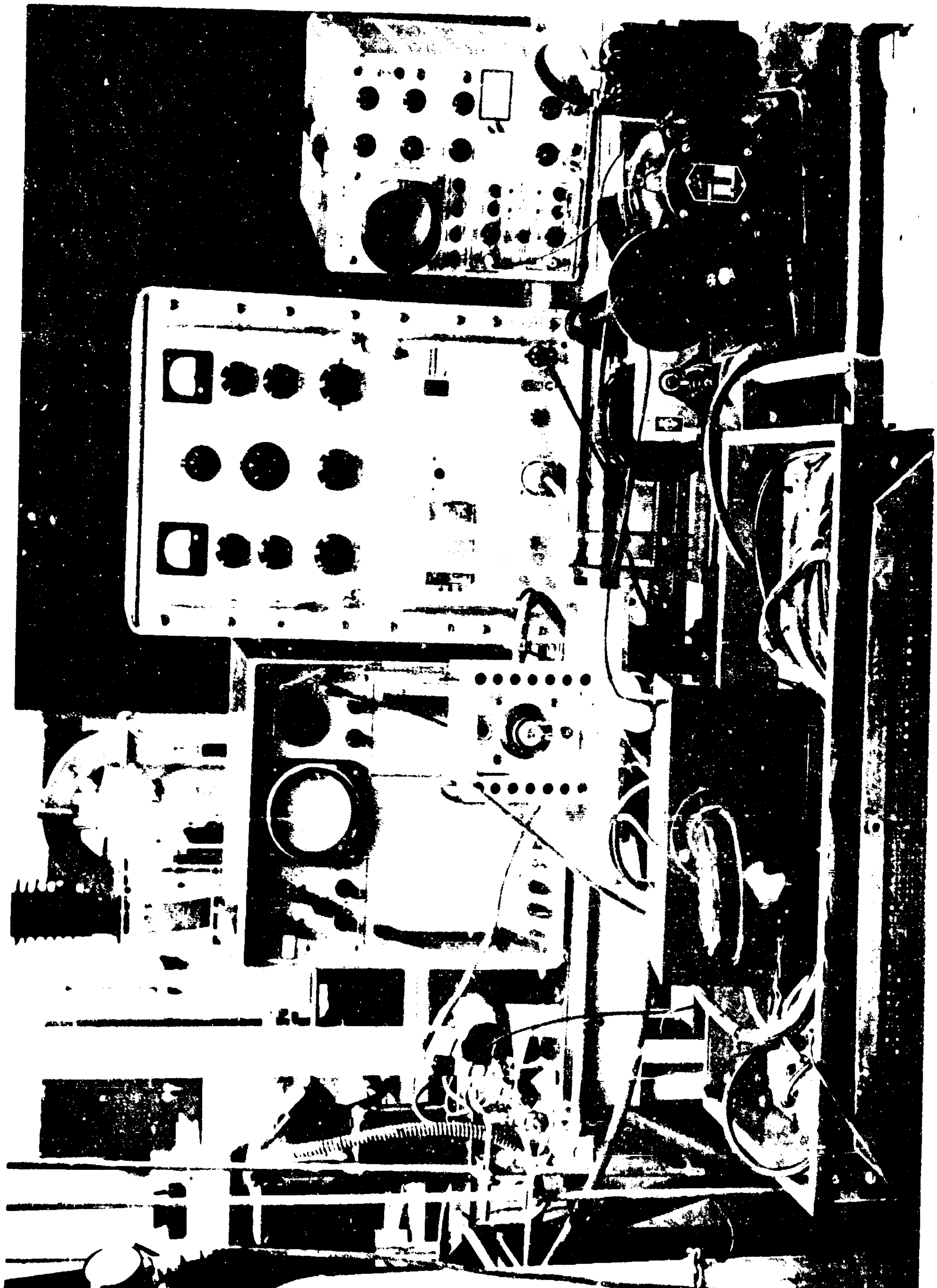


FIGURE 24

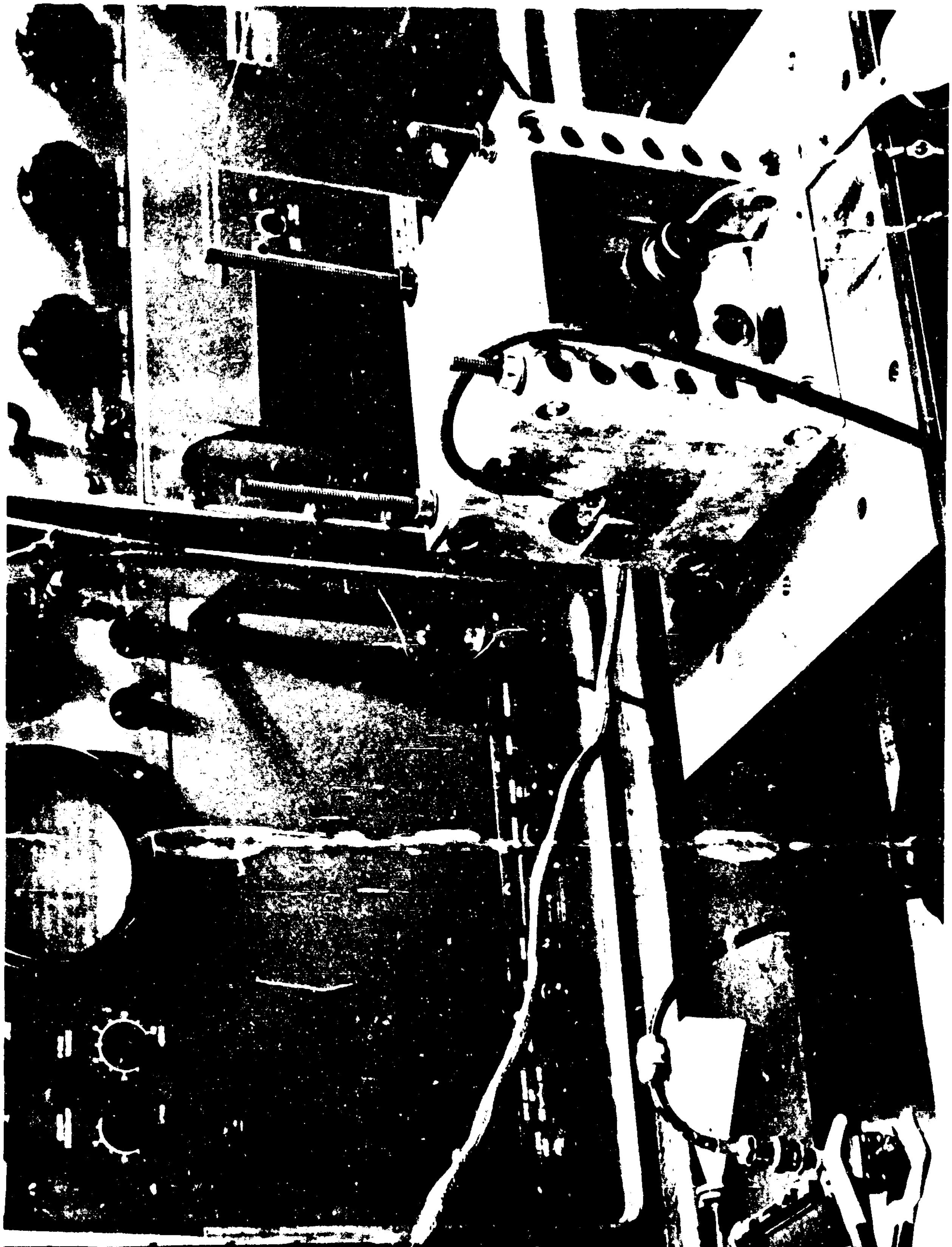


FIGURE 25

5. High Frequency Vibration (continued)

5.4 Test Results

5.4.1 The vibration test was performed after the pressurization tests. The tubes were subjected to conditions of Oscillation 2 before, during, and after vibration. Trouble was encountered when testing started on tube #72, the first to be run on the vibrator. A set of circumstances, wherein an excessive weight plus an excessively long moment arm, caused the waveguide output coupler to break loose from the magnetron. Specifically, the use of a gas pressure input adapter section, coupled with an unsupported gas pressure input hose (for SF_6 gas) contributed entirely to the unnecessarily long moment arm and excessive weight applied to the coupler. The tube was not otherwise damaged and a new coupler was soldered to the tube. The excessive torque condition was remedied and test proceeded. Examination of the test data sheet reveals that, upon retest, the tube showed no harmful effects of the accident. It was as a matter of fact a better tube due apparently to a better output circuit match.

5.4.2 All tubes successfully passed this test. Electrical results are tabulated in the Data Section.

6. Temperature Coefficient

6.1 Requirements

6.1.1 Paragraph 4.9.14 of MIL-E-1D states: "The temperature coefficient, $\Delta F/^{\circ}C$ shall be determined from the average of three tests over any 30°C temperature range. Conditions shall be as specified on the tube specification sheet. The temperature shall be that of the frequency-determining element."

6.1.2 Conditions of the TSS are as follows:

Osc. (2); T = 30°C to 100°C at point specified in Figure 1 of TSS.

$\Delta F/\Delta T$ = Temperature Coefficient. Max. = 1.8Mc/°C.

6.2 Procedure

6.2.1 Mount the tube in the Controlled Temperature Chamber (CTC) with the normal test plumbing extending outside the chamber.

6. Temperature Coefficient

6.2 Procedure (continued)

6.2.2 Adjust the chamber temperature until the point specified in Figure (1) of the TSS reaches +30°C.

6.2.3 Connect the Soft Tube Aging Modulator to the tube and preheat the cathode for 90 seconds.

6.2.4 Apply pulse voltage and operate tube under Oscillation (2) conditions as outlined under Test Procedure Para. 12.0.

6.2.5 Allow the tube to "soak" or stabilize for at least ten minutes. Measure and record temperature and frequency.

6.2.6 Increase the chamber temperature until the tube body reaches +60°C. After at least a ten minute "soak", measure and record temperature and frequency.

6.2.7 Repeat 6.2.2 and 6.2.3 at 70°C

6.2.8 Repeat 6.2.2 and 6.2.3 at 100°C

6.2.9 Calculate the temperature coefficient, TD = $\frac{\Delta f}{\Delta t}$ between +30°C and +60°C, and between +70°C and +100°C. Record on the data sheet the higher of the two figures.

6.3 Description of Test Equipment

6.3.1 The Soft Tube Ager is to be used as the pulser of this test.

6.3.2 The Associated Testing Labs temperature chamber is to be used in this test. Temperature limits of chamber are -90°C to +210°C.

6.3.3 The thermocouple and Foxboro temperature indicating device are to be used to measure the tube temperature.

6.3.4 A photograph of the setup used in the temperature coefficient measurements is shown in Figure 18.

6.4 Test Results

6.4.1 The tubes all passed the test. TC results are shown on the Qualification Data Sheets in the Data Section.

7. Pressurizing

7.1 Requirements

7.1.1 Paragraph 4.9.13 of MIL-E-1D states in part: "The tubes shall be hermetically tight after the parts noted in the outline drawing on the TSS have been gasketed as specified to a pressure chamber for one minute at the specified air pressure."

7.1.2 Note 2 of TSS states in part: "The waveguide pressure must not exceed 45 psia."

7.1.3 Note 16 of TSS states in part: "An equivalent pressure must be provided for the cathode input terminal above 6,000 feet".

7.2 Procedure

7.2.1 Attach an air pressure jig to the output flange of the tube and apply an air pressure of 45 psig to the flange.

7.2.2 Apply a liquid soap to the points associated with the waveguide output system.

7.2.3 Note and record the presence of any bubbles which may form as an indication of leaks.

7.2.4 Attach a cavity type of pressure fitting to enclose the cathode input terminal and pressure to 35 psig. "Valve Off" assemble and remove from air line and set aside for two hours.

7.2.5 Note and record any drop in pressure within the assembly as evidence of leaks.

7.3 Description of Test Equipment

7.3.1 A waveguide type air pressure jig is available to check the R.F. waveguide output system.

7.3.2 A cavity type of pressure fitting with attached pressure gauge and pressure regulator is available for pressure testing the cathode input terminal.

7.4 Test Results

7.4.1 The tubes showed no evidence of pressure leaks.

8. Low Temperature Operation

8.1 Requirements

8.1.1 MIL-E-1D states: "The tubes shall operate under the conditions specified on the tube specification sheet, following the specified warm up time at an initial ambient temperature of -65°C." Since the TSS specifies -55°C, that value applies.

8.1.2 Conditions of TSS are as follows:

Osc. (2); tk = 90 secs (max.); T = -55°C at point specified in Figure 1 of TSS.

8.2 Procedure

8.2.1 Mount the tube in the Controlled Temperature Chamber with the normal test plumbing extending outside the chamber.

8.2.2 Adjust the chamber temperature until a temperature of -55°C is obtained at the point specified in Figure 1 of the TSS.

8.2.3 Connect the Soft Tube Aging Modulator to the tube and preheat the cathode for the specified tk = 90 seconds.

8.2.4 Apply pulse voltage and operate the tube under Oscillation (2) conditions as outlined in Test Procedure Paragraph 12.0

8.2.5 Note and record ability of tube to start and operate at 9.0 amperes.

8.3 Description of Test Equipment

3.3.1 The equipment described in Section 6.3 for the temperature coefficient measurements and shown in the previously referenced photograph, Figure 18 is to be used.

8.4 Test Results

8.4.1 The tubes all started within a tk of 90 sec's and met the conditions of Oscillation (2) as indicated in the Data Section.

9. Heater Current

9.1 Requirements

9.1.1 MIL-E-1D states: "When the voltage specified on the tube specification sheet is applied to the heater or filament, the current shall be within the limits specified. During this test no other elements shall be conducting."

9.1.2 Conditions of TSS are: Ef = 6.3V, tk = 90 sec's (min), and If = 2.5 - 3.0A.

9.2 Procedure

9.2.1 Operate the tube on the Hard Tube Test Modulator with a heater potential of Ef = 6.3V.

9.2.2 Measure and record the heater current, If, at the end of 90 seconds.

9.3 Description of Test Equipment

9.3.1 Heater circuit of the Hard Tube Test Modulator, using integral heater voltage and current meters only, is to be used.

9.4 Test Results

9.4.1 The heater current of all tubes was within limits specified on TSS. Heater current values are shown in data in the Data Section.

10. Vibration Fatigue

10.1 Requirements

10.1.1 The TSS conditions are as follows:

Heater voltage only; 10G; F= 60; duration 15 min.

10.1.2 Note 4 of the TSS states: "There shall be no evidence of heater-cathode or cathode-anode shorts when the tube is vibrated in a plane perpendicular to the axis of the cathode.

10. Vibration Fatigue (continued)

10.2 Procedure

10.2.1 Bolt the vibration test jig shown in previously referenced Figure 22 to the table of the vibrator.

10.2.2 Mount the tube under test on the jig in such a way that the direction of vibration will be perpendicular to the axis of the cathode.

10.2.3 Connect an ohmmeter between the anode and cathode for the observation of anode to cathode shorts under vibration.

10.2.4 Connect cathode and filament leads of portable modulator, described in Sect. 1.6.4 to tube for observation of heater to cathode shorts. Adjust heater voltage to 6.3 volts.

10.2.5 Vibrate as specified in the TSS, note and record any anode to cathode shorts as indicated by the ohmmeter.

10.2.6 At the same time, note any heater to cathode shorts as indicated by an increase of heater current during vibration.

10.3 Description of Test Equipment

10.3.1 The vibrator is the same as described in Section 5.3.1. The ohmmeter is a "Simpson" volt-ohm meter. The filament circuit is part of the portable modulator used to provide Oscillation 2 conditions.

10.3.2 The test set up is to be the same as that shown for High Frequency Vibration in Figure 19 except that no R.F. plumbing, or spectrum viewing and measuring equipment is required.

10.4 Test Results

10.4.1 No heater-cathode or cathode-anode shorts were observed as indicated in the Data Section.

11. Oscillation (1)

11.1 Requirements

11.1.1 Paragraph 4.16.3 of MIL-E-1D states: "Each magnetron shall be tested for oscillation according to the conditions specified on the tube specification sheet."

11.1.2 The TSS calls for the following measurements to be made:

11.1.2.1 Heater-cathode warm up time, tk
11.1.2.2 Pulse Voltage, epy
11.1.2.3 Power Output, Po
11.1.2.4 *Stability, % M. P.

11.1.3 The TSS specifies the following test conditions for Oscillation (1)

11.1.3.1 Pulse Width, tp = .03±.005μs
11.1.3.2 Duty Cycle, du = .0003
11.1.3.3 Rate of rise of voltage, rrv = 325 kv/μs (min)

11.2 Procedure

11.2.1 Place the tube on the Hard Tube Test Modulator.

11.2.2 Apply a heater voltage of 6.3 volts for 90 seconds.

11.2.3 Operate the tube at 9.0 peak amperes, taking cognizance of Note 1 of TSS.

11.2.4 Note that pulse voltage and power output are nominally correct as evidence that tube operates properly after the tk = 90 seconds interval.

11.2.5 Measure and record pulse voltage and power output at t = 100 seconds after application of pulse voltage.

11.2.6 Measure and record *stability in terms of % missing pulses under conditions of Note 9 and 10 of the TSS.

11.3 Description of Test Equipment

11.3.1 Hard Tube Test Set consisting of:

11.3.1.1 Modulator in Console.

11. Oscillation (1) (continued)

11.3 Description of Test Equipment

11.3.1 Hard Tube Test Set consisting of: (continued)

11.3.1.2 Oscilloscope and Current Pulse Viewing Network.
11.3.1.3 Power Output and Pulling system, shown in Figure 17
11.3.1.4 Spectrum Analyzer, shown in some detail in Figure 16

11.4 Test Results

11.4.1 The pulse voltage, power output and stability measurement (as evidenced by the absence of missing spectrum lines over a five minute period of observation) indicated that all tubes passed the tests. Please refer to Test Data Sheets in the Data Section.

12. Oscillation (2)

12.1 Requirements

12.1.1 Paragraph 4.16.3 of MIL-E-1D states, "Each magnetron shall be tested for oscillation according to the conditions specified on the tube specification sheet."

12.1.2 The TSS calls for the following measurements to be made:

12.1.2.1 Heater-Cathode Warm-Up Time, tk
12.1.2.2 Average Anode Current, Ib
12.1.2.3 Pulse Voltage, epy
12.1.2.4 Power Output, Po
12.1.2.5 R.F. Bandwidth, BW
12.1.2.6 Minor Lobes, ML
12.1.2.7 Stability, % M.P.
12.1.2.8 Pulling Factor, P.F.
12.1.2.9 Pushing Factor, Push
12.1.2.10 Fixed Tuned Frequency, fo
12.1.2.11 **Shelf Life Stability, % M.P.
(The first measurement after 90 day shelf life)

12. Oscillation (2)

12.1 Requirements (continued)

12.1.3 The TSS specifies the following conditions for Oscillation (2).

12.1.3.1 Pulse Width, tp = .07±.01μs
12.1.3.2 Duty Cycle, du = .0005
12.1.3.3 Rate of rise of voltage, rrv = 325 kv/μs (min)

12.2 Procedure

12.2.1 Place the tube on the Hard Tube Test Modulator.

12.2.2 Apply a heater voltage of 6.3 volts for 90 seconds.

12.2.3 Operate the tube at 9.0 peak amperes anode current.

12.2.4 Note that pulse voltage and power output are nominally correct as evidence that tube operates properly after the tk = 90 seconds interval.

12.2.5 Measure and record average anode current, pulse voltage, power output, R.F. bandwidth, minor lobe relative height, stability, pulling factor, pushing factor, and fixed tuned frequency at t = 100 seconds after application of pulse voltage.

12.2.6 Measure and record **Shelf Life Stability, as the first test after the 90 day holding period.

12.3 Description of Test Equipment

12.3.1 Hard Tube Test Set - described in Section 11.3.1.

12.3.2 Frequency Pushing Measuring System, consisting of:

12.3.2.1 Standing Wave Ratio Amplifier
12.3.2.2 Frequency Meter
12.3.2.3 Crystal Detector

12.4 Test Results

12.4.1 The measurements of Heater-Cathode Warm-up time, of average anode current, pulse voltage, power output, R.F. bandwidth, minor lobe relative height, stability (as evidenced by the lack of any lines missing from the spectrum over a five minute period of observation) indicated that all tubes passed the tests. Please refer to Test Data Sheets in the Data Section.

13. Oscillation (3)

13.1 Requirements

13.1.1 Paragraph 4.16.3 of MIL-E-1D states, "Each magnetron shall be tested for oscillation according to the conditions specified on the tube specification sheet."

13.1.2 The TSS calls for the following measurements to be made:

13.1.2.1 Heater-Cathode Warm-up Time, tk
13.1.2.2 Pulse Voltage, epy
13.1.2.3 Power Output, Po

13.1.3 The TSS spe ies the following conditions for Osc. (3)

13.1.3.1 Pulse Width, tp = .25±.05
13.1.3.2 Duty Cycle, du = .0005
13.1.3.3 Rate of rise of voltage, rrv = 325 kv/μs (min)

13.2 Procedure

13.2.1 Place the tube on the Hard Tube Test Modulator.

13.2.2 Apply a heater voltage of 6.3 volts for 90 seconds.

13.2.3 Operate the tube 4.5 ma average anode current.

13.2.4 Note that pulse voltage and power output are nominally correct as evidence that the tube operates properly after the tk = 90 seconds interval.

13.2.5 Measure and record pulse voltage, and power output at t = 100 seconds after application of pulse voltage.

13.3 Description of Test Equipment

13.3.1 Hard TubeTest Set including peak voltmeter.

13.3.2 Oscilloscope and Current Pulse Viewing Network.

13.3.3 Power Output Measuring System.

13.4 Test Results

14.4.1 The measurements of Heater-Cathode Warm-up Time, Pulse Voltage and Power Output indicated that all tubes passed the tests. Please refer to Test Data Sheets in the Data Section.

14. Acceptance Life Test

14.1 Requirements

14.1.1 Paragraph 4.11 of MIL-E-1D states in part: "When specified on the tube specification sheet, sample tubes shall be subjected to life tests ---".

14.1.2 The TSS specifies a life of 600 cycles under a specific cycling schedule in which standby, oscillation and off periods are used.

14.2 Procedure

14.2.1 Place the tube on the Life Test Modulator.

14.2.2 Set the timers on the modulator to produce the specified cycling time intervals.

14.2.3 Connect the plumbing to the tube and pressurize same with dry nitrogen.

14.2.4 Apply the specified starting heater voltage.

14.2.5 Apply pulse voltage to the tube and adjust the power supply voltage to produce the rated ib = 9.0 amperes.

14.2.6 Immediately upon reaching 9.0 amperes, reduce the heater voltage to obtain the predetermined operating current.

14.2.7 Allow unit to cycle, shutting down and moving the tube to the Hard Tube Test Set for periodic performance tests.

14.2.8 During the periodic tests, under the Cycling Life Test End Point conditions of the TSS, read and record under Osc. (1) power output and peak anode voltage, and under Osc. (2) read and record oscillation frequency, bandwidth, stability, and peak anode voltage.

14.2.9 Discontinue the test after 600 cycles have elapsed.

14.3 Description of Test Equipment

14.3.1 Soft Tube Life Test Set, - described in detail in Section 1.6.3 and shown in Figure 19

14.3.2 Motor Driven Pulling Device.

14. Acceptance Life Test

14.3 Description of Test Equipment (continued)

14.3.3 Dry Load

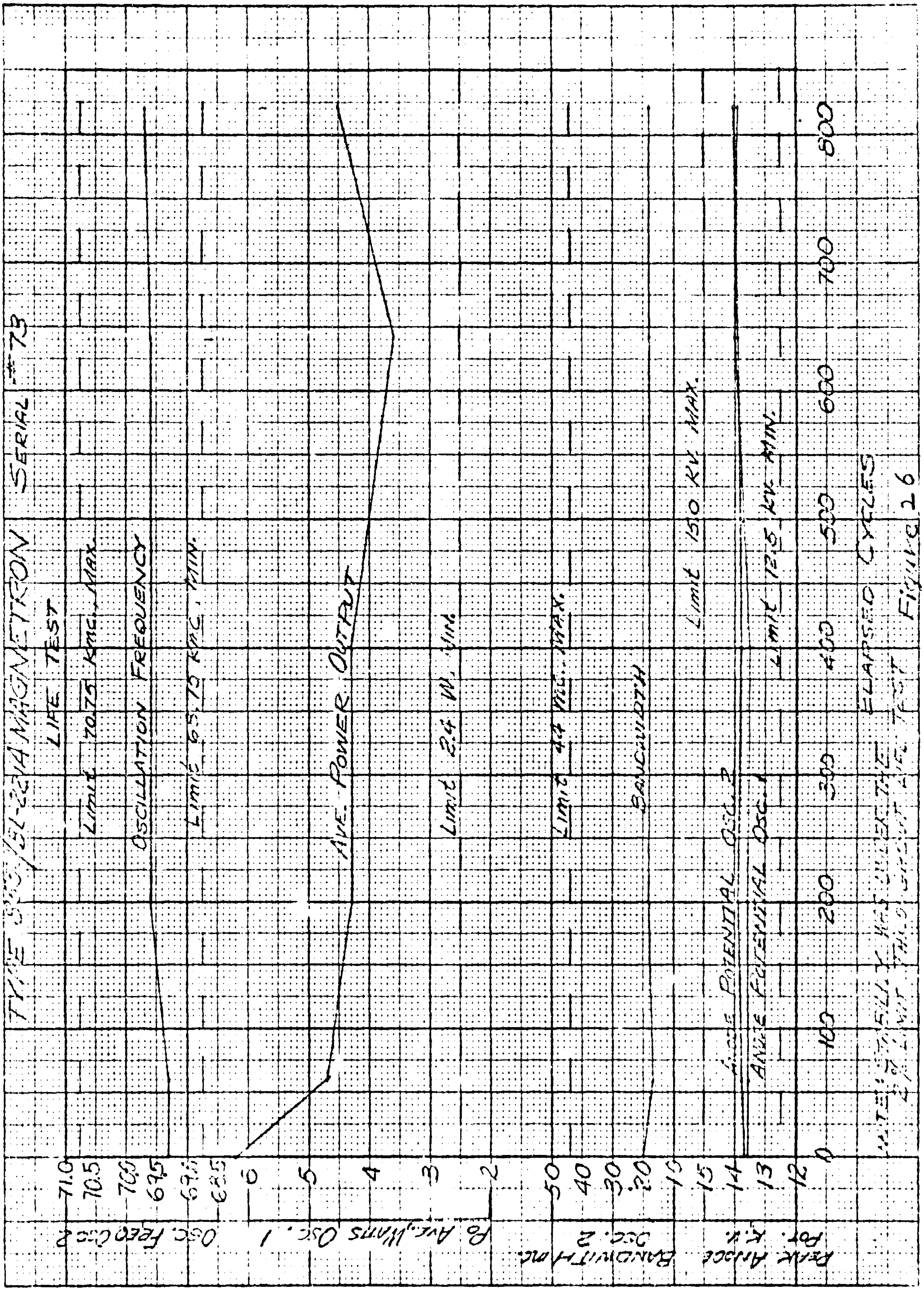
14.3.4 Waveguide Pressurizing System

14.3.4.1 Dry Nitrogen from plant line, pressure regulator and hose to plumbing.

14.4 Test Results

14.4.1 The measurements on the selected tube, #73 under Cycled Life Tests End Point conditions at the end of 640 cycles, shown in the Data Section indicate satisfactory compliance with the requirements of the TSS. The results are shown graphically in Figure 26.

14.4.2 In addition to the tube which was life tested during the preproduction approval testing, five (5) other tubes were evaluated to determine acceptability of the anode processing changes. Tubes 44, 49, 55, 57 and 61 all maintained reasonably constant readings through shelf storage. Tubes 55 and 57 were life tested to 1239 and 1159 cycles respectively. At 757 cycles tube 55 exceeded the end of life anode voltage limit but still performed satisfactorily. At 1239 cycles the power was less than the end of life limit of 8 kw. At 797 cycles and again, after recovery, at 1025 cycles tube 57 exceeded the end of life anode voltage limit but otherwise continued to operate satisfactorily to 1150 cycles when the test was terminated.


MAGNETRON SERIAL #73
LIFE TEST
Limit 70.75 Kmc. Max.
OSCILLATION FREQUENCY
AVE. POWER OUTPUT
Limit 2.4 W. Min.
Limit 44 Mc. Max.
BANDWIDTH
Limit 15.0 KV. Max.
Anode Potential Osc. 2
Anode Potential Osc. 1
Limit 12.5 KV. Min.
ELAPSED CYCLES
Osc. Freq Osc. 2
Osc. 1
Po Ave. Watts Osc. 1
Osc. 2
Bandwidth Mc.
Peak Anode Pot. KV.
71.0
70.5
70.0
69.5
6
5
4
3
2
50
40
30
20
10
15
14
13
12
0
100
200
300
400
500
600
700
800
Figure 26

SUMMARY OF DATA

The original data, reorganized on individual test data sheets for the five tubes, is shown in the Data Section which follows the Discussion of Results and Conclusions. All data, except the initial value of filament current, is tabulated. The filament current for each tube is shown in Note 4 on each sheet. Notes 1, 2, 3, 5, 6, 7, 8, and 9 apply to all four tubes subjected to the environmental tests. Notes 10, 11, and 12 have specific meaning for the different tubes involved.

Close scrutiny of the test conditions near the left side of the sheets and cognizance of the significance of Note 2 will reveal that pulse width conditions on Oscillation 1 testing are not quite according to specification. Whereas the minimum pulse width is supposed to be .025 μsec it is actually .024 μsec. Several attempts were made to achieve satisfactory rise time and pulse shape with a different network to give a longer pulse but all failed. Since the Oscillation 1 condition is the shortest pulse in the specification the actual condition serves to broaden the testing scope rather than to narrow it. In view of this it is requested that the data be accepted as consistent with the intent of the specification.

It will be noted that certain entries in the data have been shown as "OK". In the case of the three stability measurements, the spectra were observed critically for missing lines, none were seen and missing pulse measurements were not made. Consider the fact that 1% missing lines corresponds with 22 lines per second at 2200 pulses per second, the minimum prf. One can rationalize that it is not difficult to visually determine from spectrum observation whether the M/P limit is being approached merely by counting lines which seem to be less than normal amplitude during a one second period. It is certain that a spectrum wherein 22 lines per second are seen to be deficient would be an outstandingly ragged one. Had the latter been the case, % missing pulse measurements would have been made.

In the case of Vibration Fatigue and Low Temperature Operation, the entry of "OK" is to indicate that (1) no shorts occurred and (2) the tube operated satisfactorily at 9.0 amperes.

In the case of Shock, the entry of "OK" is to indicate that the tubes performed satisfactorily after shock as indicated by the Post-Shock data.

Reivew of the Test Data Sheets reveals that minor changes only occurred in the magnetrons tested, during and due to the vibration, shock,

Summary of Data (continued)

shelf life and routine testing to which they were subjected. Review of the Life Test Data reveals that the readings of average power output show the greatest variation with a sizeable drop during the first 58 cycles. However, the minimum power observed during life exceeds the minimum limit by a good margin. The other indications fall well within the specified limits throughout the 820 satisfactory life cycles. The graph shown in Figure 26 presents these results.

Photographs showing representative pulse shapes produced by the Hard Tube Test Modulator are shown in Figure 27. The well known pulse current which serves to charge the incidental pulse output circuit capacitances is noticeable at the start of the current pulse. It is noticeable also by its absence from the R. F. pulse and is thereby identified as a charging current. All pulses are shown in the correct time relationship.

Pulse Photographs of Hard Tube Modulator

.03 μs Pulse

#1 Voltage
#2 Current
#3 R. F.

.07 μs Pulse

#1 Voltage
#2 Current
#3 R. F.

.25 μs Pulse

#1 Voltage (expanded)
#2 Voltage
#3 Current
#4 R. F.

Note: Sweep Direction is Right to Left

FIGURE 27

DISCUSSION OF RESULTS AND CONCLUSIONS

During environmental testing, one failure occurred. It was during vibration fatigue testing of the second tube that the output flange broke off the output flange support sleeve. The hard braze material used to join these two parts fractured. Two errors were found in the testing arrangement. First, instead of the specified 10 G vibration level, the tube was run with 14.5 G's. This occurred because the amplitude was not decreased from the .04 inches used on the operational vibration test while the frequency was increased from 50 to 60 cps. Secondly, the arrangement of plumbing and the attached hose supplying SF_6 gas to the waveguide was such that an excessive moment arm and weight resulted in excessive mechanical loading of the flange. The tube was reworked by soldering a new output flange and support sleeve assembly to the magnetron. On subsequent retest the tube delivered more power output. This variation could have been expected since the output window match is critically dependent on flange to window spacing. The tube was then re-run on a corrected test apparatus on all previous tests and carried through the remainder of the QA sequence without incident.

It might be noted on Oscillation 2 testing that the average current values on two of the tubes at some time during the testing sequence read less than the specified 4.5 mAdc. If the duty cycle reading and the set value of peak current were precise this situation would not be possible. However, duty cycle is computed with an assumed trapazoidal pulse and the peak current setting using a viewing resistor and oscilloscope is subject to operator judgement. The purpose of indicating limit values of average current was to prevent a magnetron having a high leakage from successfully passing the test. Since high leakage would invariably cause high average currents it is recommended that the 4.5 mAdc minimum average current limit be deleted from the specification.

These tests demonstrate that the tube is capable of meeting all of the requirements of the applicable BL-221 specification dated 9-23-63 and approved by the Signal Corps on 10-23-63.

[illegible] SHEET [illegible] MAGNETRON - QUALIF[illegible]

TEST CONDITION	INITIALS	TEST DATE	TEST PHASE	PULSE REPETITION RATE (PPS)	PULSE WIDTH (μS)	DUTY CYCLE	FILAMENT POTENTIAL (VOLTS)	FILAMENT CURRENT (AMPS)	PEAK ANODE CURRENT	PEAK [illegible]	[illegible] OPERATING [illegible]
			SYMBOL →	f_r	t_p	D_u	E_f	I_f	i_b	e_{by}	P_o
OSC 1	LIMITS		MINIMUM	Not Specified	.025	.0003 Nom.	Note 4	Note 4	9.0 Nom.	12.5	3.0
			MAXIMUM		.035 Note 2					14.6	-
	[illegible]	12/5/63	Initial Test	11,200	.022	.00025	2.07	1.3	9.0	13.7	3.3
	[illegible]	12/11	Post-Shock	11,200	.022	.00025	2.07	1.3	9.0	13.5	3.7
	[illegible]	12/18	Pre-Shelf	11,200	.024	.00027	2.07	1.3	9.0	13.6	3.4
OSC. 2	LIMITS		MINIMUM	Not Specified	.06	.0005 Nom.	Note 4	Note 4	9.0 Nom.	12.5	5.0
			MAXIMUM		.08					14.6	
	[illegible]	12/5	Initial Test	6,250	.08	.0005	2.07	1.3	9.0	13.8	7.0
	[illegible]	12/10	Post-Vib.	6,250	.08	.0005	2.07	1.3	9.0	13.7	8.5
	[illegible]	12/11	Post-Shock	6,250	.075	.00046	2.07	1.3	9.0	13.5	7.8
	[illegible]	12/18	Pre-Shelf	6,250	.08	.0005	2.07	1.3	9.0	13.6	6.7
	[illegible]	3/19/64	Final	6,250	.08	.0005	2.07	1.3	9.0	13.6	7.3
OSC. 3	LIMITS		MINIMUM	Not Specified	.20	.0005 Nom.	Note 4	Note 4	9.0 Nom.	12.5	5.0
			MAXIMUM		.30					14.6	-
	[illegible]	12/5	Initial Test	2,420	.22	.00053	2.07	1.3	9.0	13.8	7.0
	[illegible]	12/11	Post-Shock	2,420	.22	.00053	2.07	1.3	9.0	13.5	8.0
	[illegible]	12/18	Pre Shelf #1	2,420	.22	.00053	2.07	1.3	9.0	13.4	6.9
	[illegible]	12/19	Pre Shelf #2 NOTE 5	2,420	.22	.00053	2.07	1.3	[illegible]	13.4	7.9
	[illegible]	12/19	Pre Shelf #3 NOTE 5	2,280	.22	.0005	2.07	1.3	[illegible]	13.4	7.8

NOTES:

1. Tests performed 12/4 to 12/6 Witnessed by Simon Zucker [illegible]AEM[illegible] All tests were witnessed by Harry [illegible] Isaac Jr. [illegible]AREP, BOSTON Procurement District
2. Investigation by Eng. personnel indicates a probable read[illegible] error in Oscillation (1) pulse width. All values should have been 0.024 microseconds.

WITNESSES: For Signal Corps. Harry [illegible] Simon Zucker USA, [illegible] For Bomac Div R.C. Sibley

Peak Current (Amps) · Peak Anode Current (Amps) · Peak Anode Potential · Stability · Figure · Osc Frequency (KMCS) · Vibration Fatigue · Frequency

	Note 4	Note 4	9.0 Nom.	12.5 14.6	3.0 -		- 1%											
	2.07	1.3	9.0	13.7	3.3		OK											
	2.07	1.3	9.0	13.5	3.7		OK											
	2.07	1.3	9.0	13.6	3.4		OK											
	Note 4	Note 4	9.0 Nom.	12.5 14.6	5.0	4.5 5.5	- 1%	-	- 5.12	9.6 -	- 75	69.9 70.5	5	See Note 4	-	-	- 1.9	9.0 Nom.
4	2.07	1.3	9.0	13.8	7.0	4.5	OK		19.8	OK	48	70.4	0					
4	2.07	1.3	9.0	13.7	8.5	4.5	OK		20.0	OK	48	70.2	0	OK				
4	2.07	1.3	9.0	13.5	7.8	4.5	OK		18.0	OK	48	70.3	0				1.42	OK
4	2.07	1.3	9.0	13.6	6.7	4.3	OK		20.4	OK	48	70.38	0					
4	2.07	1.3	9.0	13.6	7.3	4.5			19	OK	48	70.4						
	[illegible]	Note 4	9.0 Nom.	12.5 14.6	8.0 -	4.5 Nom.												
	2.07	1.3	9.0	13.8	7.0													
	2.07	1.3	9.0	13.5	8.0													
	2.07	1.3	9.0	13.4	6.9													
4	2.07	1.3		13.4	7.9	4.5												
4	2.07	1.3		13.4	7.8	4.5												

3. Plane X_1 is perpendicular to cathode a...
Plane X_2 is perpendicular to cathode a...
Plane Y is parallel to cathode axis and ...
4. Operating values are shown the initial v...
5. Initial, post vibration, post shock and pre...
with pulse current set at 9.0 amps. peak
... the pulse current at 4.5 mA dc
The data is shown as pre-shelf #2
... rise of voltage ... 62 KV/...
... terminal pressure test ... 5.63 ...
8. All tubes were held for 163 hours befo...
9. All tubes oscillated satisfactorily a...
10. General note, #73 placed on life te...
... testing three being req...
... tests. After 90 day shelf test ...
required tests under Osc. 2 plus ...
was tested additionally under Osc.
11. Tube 69 delivered to QA Rep. 12/19/63

... Simon Zucker ... SAEMDA
... Isaac ... AREF

... a process ... using
All values ...

C. Kirby

T DATA (note 1) TUBE No 69 Sys 72

M.	M.L.	P.F.	f_0	Duty	Δt	Δf	T.C.	i_A	
B.4	-		69.0		See Note 4	-	-	-	0.0	See Note 3
2	-	75	70.5	5		-	-	1.5	Nom.	
8	OK	48	70.4	0						
.0	OK	48	70.2	0	OK					
0	OK	48	70.3	0				1.42	OK	OK
4	OK	48	70.38	0						
	OK	48	70.4							

Vib. Plane	B.W.	ΔP	H.G. Output Press (Leaks)	Holding Period	WC Warm-up Time	Outline Dim.	Life
	-	-	See Note 8 Below	See Note 9 Below	See Note 10 Below	See Data Page 2	
	37	0					
		0					
Vib. Plane	Band Width						
X_1	26.0						
Y	24.0						
X_2	26.0						
Note 3							

FIGURE 28

X_1 is perpendicular to cathode axis and parallel to output.
X_2 is perpendicular to cathode axis and perpendicular to output.
Y is parallel to cathode axis and perpendicular to output.
...ing values are shown. The initial values were 6.3 v at 2 am. See Spec Note
...post vibration, post shock and pre shelf tests were preformed
...ulse current set at 20 amps peak. The tubes were re-read
...g the pulse current at 4.5 mA dc and at two duty cycles.
...ata is shown as pre-shelf #2 and pre-shelf #3 under Osc. (?)
...t rise of voltage ... kv/us for all tests
...terminal pressure test ... revealed zero leakage on the 4 tubes
...ubes were held for 45 hours before qualification testing.
...ubes oscillated satisfactorily at the end of the 90 second warm-up
...ral note #73 placed on the test ... For tubes subjected
...e pres testing three being required. The four tubes passed
...ests. After 90 day shelf test, all four tubes passed the
...res tests under Osc. 2 plus outline dimensions. Tube 70
...ired additionally under Osc. 1 and 3
69 delivered to GA Rep. 12/13/63 as a Test Standard

[illegible] MAGNETRON [illegible]

	TEST CONDITION	INITIALS	TEST DATE	TEST PHASE	PULSE REPETITION RATE (PPS)	PULSE WIDTH (MS)	DUTY CYCLE	FILAMENT POTENTIAL (VOLTS)	FILAMENT CURRENT (AMPS)	PEAK ANODE [illegible]	[illegible]
				SYMBOL →	PRR	t_p	D_u	E_f	I_f	e_b	e_{py}
OSC 1	LIMITS			MINIMUM / MAXIMUM	Not Specified	.025 / .033 Note 2	.0003 Nom.	Note 4	Note 4	9.0 Nom.	12.5 / 14.6
			12/5/63	Initial Test	11,200	.022	.00025	2.07	1.3	9.0	14.2
			12/6	Retest	11,200	.022	.00025	2.07	1.3	9.0	14.4
			12/11	Post Shock	11,200	.022	.00025	2.07	1.3	9.0	14.4
			12/18	Pre Store	11,200	.024	.00027	2.07	1.3	9.0	14.2
OSC 2	LIMITS			MINIMUM / MAXIMUM	Not Specified	.06 / .05	.0005 Nom.	Note 4	Note 4	9.0 Nom.	12.5 / 14.6
			12/5	Initial Test	6,250	.05	.0005	2.07	1.3	9.0	14.3
			12/9	Retest	6,250	.08	.0005	2.07	1.3	9.0	14.5
			12/10	Post Vib	6,250	.08	.0005	2.07	1.3	9.0	14.5
			12/11	Post Shock	6,250	.08	.0005	2.07	1.3	9.0	14.5
			12/18	Pre Store	6,250	.08	.0005	2.07	1.3	9.0	14.2
			3/11/64	[illegible]	6,250	.08	.0005	2.07	1.3	9.0	14.1
OSC 3	LIMITS			MINIMUM / MAXIMUM	Not Specified	[illegible] / .30	[illegible] Nom.	Note 4	Note 4	9.0 Nom.	12.5 / 14.6
			12/5	Initial Test	2,420	.22	.00053	2.07	1.3	9.0	14.3
			12/9	Retest	2,420	.21	.00051	2.07	1.3	9.0	14.5
			12/11	Post Shock	2,420	.22	.00053	2.07	1.3	9.0	14.5
			12/18	Heat [illegible]	2,420	.22	.00053	2.07	1.3	9.0	14.4
			12/18	Pre Store	2,420	.22	.00053	2.07	1.3	[illegible]	14.4
			12/18	[illegible]	2,480	.22	.0005	2.07	1.3	[illegible]	14.4

NOTES: 1. Test performed [illegible] by [illegible] ARE [illegible]

2. [illegible] by [illegible] error in [illegible] values [illegible]

WITNESSES: [illegible]

Harry [illegible]

Simon Fischer USA, EMSA

R C [illegible]

A

… QUALIFICATION TEST DATA (note 1) … TYPE …

	I_f	E_f	e_{by}	P_0	I_b	AMP	B.W.	ML	P.F.	f_0	Push		ΔT	Δf	T.C.		
	Filament (volts)	Filament current (amps)	Peak anode current (amps)	Peak anode potential (KV)	A Peak RF watts	Av anode current (ma)	Stability	Bandwidth (mcs)	Major lobes	Pulling figure	Osc. frequency (KMCS)	Pushing figure	Vibration failures	Temp. change	Freq. change MCS	Temp. coefficient	Low temp.
4 [illegible] 4		9.0	14.5	3.0		–											
		Nom.	14.6	–		1%											
	1.3	9.0	14.2	3.1		OK											
	1.3	9.0	14.4	5.0		OK											
	1.3	9.0	14.4	6.5		OK											
	1.3	9.0	14.2	4.5		OK											
4 [illegible] 4		9.0	14.5	5.0	4.5	–	–	–	3 db	–	69.0		See Note 4	–	–	9.0	See Note 3
		Nom.	14.6		5.5	1%		31.2	–	35	70.5				1.5	Nom.	
	1.3	9.0	14.3	5.5	4.5	OK		48.4	OK	32	70.3	0					
	1.3	9.0	14.5	10.5	4.5	OK		49.0	OK	48	70.4	0					
	1.3	9.0	14.5	11.	4.5	OK		49.0	OK	48	70.3	0	OK				
	1.3	9.0	14.5	11.	4.5	OK		49.0	OK	48	70.3	0			0.427	OK	OK
	1.3	9.0	14.2	9.2	4.5	OK		49.6	OK	48	70.2	0					
	1.3	9.0	14.1	7.7	4.5		OK	24	OK	48	70.19						
[illegible] 4		9.0	[illegible]	[illegible]	4.5												
		Nom.	14.6	–	Nom.												
	1.3	9.0	14.3	6.0													
	1.3	9.0	14.5	8.3													
	1.3	9.0	14.5	11													
	1.3	9.0	14.4	8.3													
	1.3		14.4	9.2	4.5												
	1.3		14.4	9.0	4.5												

[illegible] SAE M5A
[illegible] WAKER.

[illegible] values [illegible]

3. Plane X_1 is perpendicular to cathode axis. Plane X_2 is perpendicular to cathode axis. Plane Y is parallel to cathode axis and perp[illegible]
4. Operating values are [illegible]
[illegible] Initial, post vibration, post shock and pre [illegible] with pulse current set at 10 amps peak [illegible] [illegible] current at 4.5 ma dc [illegible] [illegible] shown as pre-shelf #2 [illegible] [illegible] of voltage [illegible] input [illegible] pressure [illegible]
[illegible] All tubes were held for [illegible] hours [illegible]
9. All tubes [illegible] [illegible]
0. General note [illegible] placed on [illegible] to pre-prod testing, three [illegible] requires [illegible] tests. After [illegible] shelf test, [illegible] requires tests under [illegible] plus [illegible] [illegible]
1. During performance of vibration, equipment [illegible] to [illegible] off coupler was [illegible] installed and tube [illegible]

B

MODE CURRENT (ma) | STABILITY & SHELF LIFE STABILITY | BANDWIDTH (MCS) | MINOR LOBES (db down) | PULLING FIGURE (MCS) | OSC. FREQUENCY (KMCS) | PUSHING FIGURE / VIBRATION FATIGUE & 2 SHOCKS | TEMP. CHANGE °C | FREQ. CHANGE MCS | CALC. TEMP. COEFFICIENT | TEMPERATURE COEF. | LOW TEMP. OPERATION AT i₀ (AMP) | SHOCK (see data) | VIBRATION BAND WIDTH | W.G. OUTPUT PRESS. (LEAKS) | HOLDING PERIOD | W.G. WARMUP TIME | OUTLINE DIM.

M.P.	B.W.	M.L.	P.F.	f_o	Osc		Δt	Δf	T.C.	i_L	
-	-	9 db	-	69.0		See Note 4	-	-	-	9.0	See Note 3
[illegible]	31.2	-	75	70.5	5			-	1.5	Nom.	
	18.4	OK	32	70.3	0						
	19.0	OK	48	70.4	0						
	19.0	OK	48	70.3	0	OK					
	19.0	OK	48	70.3	0				0.427	OK	OK
	19.6	OK	48	70.2	0						
OK	24	OK	48	70.19							

VIBRATION PLANE	BAND WIDTH (B.W.)	ΔP				
	-	-				
	37	0				
		0				
X	20.0		SEE NOTE 8 BELOW	SEE NOTE 9 BELOW	SEE NOTE 10 BELOW	SEE DATA PAGE 2
Y	20.8					
X_1	20.0					

FIGURE 29

12. Tube #12 delivered to QA [illegible] 12/19/63 as a Test Standard

3. Plane X_1 is perpendicular to cathode axis and parallel to output. Plane X_2 is perpendicular to cathode axis and perpendicular to output. Plane Y is parallel to cathode axis and perpendicular to output.
4. Operating values are [illegible] [illegible] values were 6.3 v at 2.7 a. See [illegible] Note
5. Initial, post vibration, post shock and pre shelf tests were preformed with pulse current set at 10 amps peak. The tubes were re-read, setting the pulse current at 4.5 mA dc and at two duty cycles. The data is shown as pre-shelf #2 and pre-shelf #3 under Osc. [illegible]
6. Rate of rise of voltage was 82 KV/µs for all tests.
7. Input terminal pressure test 12-5-63, revealed zero (0) leakage on the [illegible]
8. All tubes were held for 165 hours before qualification testing.
9. All tubes oscillated satisfactorily at the end of the 90 second warm[illegible]
10. General note, #73 placed on life test 11-18-63. Four tubes subjected to pre-prod testing, three being required. The four tubes passed all tests. After 90 day shelf test, all four tubes passed the required tests under Osc. 2 plus outline dimensions. Tube 74 was tested additionally under Osc. 1 and 3.
11. During performance of vibration, equipment resonance caused output coupler to come off. Coupler was re-installed and tube completely retested.

C

DATA SHEET [illegible] MAGNETRON - QUALIFICATIO

TEST CONDITION	INITIALS	TEST DATE	TEST PHASE	PULSE REPETITION RATE (PPS)	PULSE WIDTH (µS)	DUTY CYCLE	FILAMENT POTENTIAL (VOLTS)	FILAMENT CURRENT (AMPS)	OPERATING PEAK ANODE CURRENT (AMPS)	PEAK ANODE POTENTIAL	P_o	
			SYMBOL →	prr	t_p	d_u	E_f	I_f	i_b	e_{py}	P_o	
OSC 1	LIMITS		MINIMUM	Not Specified	.025	.0003 Nom.	Note 4	Note 4	9.0 Nom.	12.5	3.0	
			MAXIMUM		.035 Note 2					14.6	–	
	[illegible]	12/5/63	Initial Test	11,200	.022	.00025	1.50	1.1	9.0	14.5	3.8	
	[illegible]	12/11	Post-Shock	11,200	.022	.00025	2.07	1.3	9.0	14.3	3.6	
	[illegible]	12/18	Pre-Shelf	11,200	.024	.00027	2.07	1.3	9.0	14.2	3.3	
	[illegible]	3/19/64	Final Test	11,200	.024	.00027	2.07	1.3	9.0	14.2	3.5	
OSC 2	LIMITS		MINIMUM	Not Specified	.06	.0005 Nom.	Note 4	Note 4	9.0 Nom.	12.5	5.0	4.
			MAXIMUM		.08					14.6		5.
	[illegible]	12/5	Initial Test	6,250	.08	.0005	1.50	1.1	9.0	14.5	6.0	4
	[illegible]	12/10	Post-Vib.	6,250	.08	.0005	2.07	1.3	9.0	14.4	7.0	4.
	[illegible]	12/11	Post-Shock	6,250	.08	.0005	2.07	1.3	9.0	14.5	6.0	4.
	[illegible]	12/18	Pre-Shelf	6,250	.08	.0005	2.07	1.3	9.0	14.4	5.9	4.
	[illegible]	3/19/64	Final	6,250	.08	.0005	2.07	1.3	9.0	14.3	5.7	4.
OSC 3	LIMITS		MINIMUM	Not Specified	.20	.0005 Nom.	Note 4	Note 4	9.0 Nom.	12.5	5.0	4.
			MAXIMUM		.30					14.6	–	N.
	[illegible]	12/5	Initial Test	2,420	.21	.00051	2.07	1.3	9.0	14.5	5.5	
	[illegible]	12/11	Post Shock	2,421	.22	.00052	2.07	1.3	9.0	14.3	6.0	
	[illegible]	12/18	Pre Shelf #1	2,420	.22	.00053	2.07	1.3	9.0	14.4	5.6	
	[illegible]	12/18	Pre Shelf #2 NOTE 5	2,420	.22	.00055	2.07	1.3	[illegible]	14.4	6.1	4
	[illegible]	12/18	Pre Shelf #3 NOTE 5	2,280	.22	.0005	2.07	1.3	[illegible]	14.4	5.9	4
	[illegible]	3/19/64	Final Test	2,280	.22	.0005	2.07	1.3	[illegible]	14.3	5.5	

NOTES:
1. Tests performed 12/4 to 12/6 Witnessed by Simon Zucker, USAEMS
All tests were witnessed by Harry C. Isaac Jr. QAREP. BOSTON Procurement District
2. Investigation by Eng personnel indicates a probable readi[ng] error in Oscillation (1) pulse width. All values should have been 0.024 microseconds.

WITNESSES: For Signal Corps: Harry C. Isaac Jr. — Simon Zucker USD, [illegible]
For [illegible] Div: R.C. Hubley

A

MAGNETRON - QUALIFICATION TEST DATA (note 1) TUB

t_u (Pulse Width (μs))	E_f (Filament Potential (Volts))	I_f (Filament Current (Amps))	i_b (Peak Anode Current (Amps))	e_{py} (Peak Anode Potential (K.V.))	P_o (RF Power Output (Watts))	I_b (Av. Anode Current (MA))	% M.P.		B.W. (Bandwidth (MCS))	M.L. (Minor Lobes (db down))	P.F. (Pulling Figure (MCS))	f_o (Osc. Frequency (KMCS))	Push.		Δz	Δf	T.C.	i_b
.0003 Nom.	Note 4	Note 4	9.0 Nom.	12.5 / 14.6	3.0 / -		- / 1%											
.00025	1.50	1.1	9.0	14.5	3.8		OK											
.00025	2.07	1.3	9.0	14.3	3.6		OK											
.00027	2.07	1.3	9.0	14.2	3.3		OK											
.00027	2.07	1.3	9.0	14.2	3.5													
.0005 Nom.	Note 4	Note 4	9.0 Nom.	12.5 / 14.6	5.0	4.5 / 5.5	- / 1%	- / 2%	- / 31.2	8 db / -	- / 75	69.0 / 70.5	5	Spec. Note 4	- / -	- / -	- / 1.8	9.0 Nom.
.0005	1.50	1.1	9.0	14.5	6.0	4.6	OK		18.0	OK	48	69.67	0					
.0005	2.07	1.3	9.0	14.4	7.0	4.5	OK		20.0	OK	48	69.7	0	OK				
.0005	2.07	1.3	9.0	14.5	6.0	4.5	OK		18.5	OK	48	69.6	0				1.577	OK
.0005	2.07	1.3	9.0	14.4	5.9	4.6	OK		18.0	OK	48	69.7	0					
.0005	2.07	1.3	9.0	14.3	5.7	4.8		OK	24	OK	48	69.85						
.0005 Nom.	Note 4	Note 4	9.0 Nom.	12.5 / 14.6	5.0 / -	4.5 Nom.												
.00051	2.07	1.3	9.0	14.5	5.5													
.00052	2.07	1.3	9.0	14.3	6.0													
.00053	2.07	1.3	9.0	14.4	5.6													
.00053	2.07	1.3		14.4	6.1	4.5												
.0005	2.07	1.3		14.4	5.9	4.5												
.0005	2.07	1.3		14.3	5.5	4.5												

...ssed by Simon Zucker USAEMSA
Harry .. Isaac Jr. CAREP
...trict
...indicate a probable reading
...which. All values should
...rss.

For ... Div
R.C. ...

3. Plane X_1 is perpendicular to cathode ...
Plane X_2 is perpendicular to cathode ...
Plane Y is parallel to cathode axis an...
4. Operating values are shown. The initial ...
5. Initial, post vibration, post shock and ...
with pulse current set at 9.0 amps. Pe...
setting the pulse current at 4.5 mA ...
The data is shown as pre-shelf ...
6. Rate of rise of voltage, rrv = 62 K...
7. Input terminal pressure test, 12-5-63, ...
8. All tubes were held for 168 hours be...
9. All tubes oscillated satisfactorally ...
10. General note, #73 placed on life t...
to pre-prod testing, three being r...
all tests. After 90 day shelf test ...
required tests under Osc. 2 plus o...
was tested additionally under Os...
11. Tube 74 placed on 90 day official ...

B

TEST DATA (note 1) TUBE No. 74 Page 74

[illegible]	B.W.	M.L.	P.F.	f_o	[illegible]		Δt	Δf	T.C.	i_b	
Current	Stability & Stability / Shelf Life Stability / Bandwidth (MCS)	Minor Lobes (db down)	Pulling Figure (MCS)	Osc. Frequency (KMCS)	Pushing Figure	Vibration Fatigue	Temp. Change °C	Freq. Change MCS	Calc. Temp. Coefficient (Temperature Coef.)	Low Temp. Operation at i_b (amps)	Shock (See data)
	-	8db	-	69.0		Spec Note 4	-	-	--	9.0 Nom.	Spec Note 3
	31.2	-	75	70.5	5		-	-	1.8		
	18.0	OK	48	69.67	0						
	20.0	OK	48	69.7	0	OK					
	18.5	OK	48	69.6	0				1.577	OK	OK
	18.0	OK	48	69.7	0						
	24	OK	48	69.85							

Vib. Plane	Vibration Band Width (B.W.)	W.G. Output Press. (Leaks) (ΔP)	Holding Period	WC Warmup Time	Outline Dim.	Life
	-	-	See Note 8 Below	See Note 9 Below	See Note 10 Below	See Data Page 2
	37	0				
		0				
X_1	23.0					
Y	24.0					
X_2	28.0					
Note 3						

FIGURE 30

[illegible]ane X_1 is perpendicular to cathode axis and parallel to output.
[illegible]ne X_2 is perpendicular to cathode axis and perpendicular to output.
[illegible]ne Y is parallel to cathode axis and perpendicular to output.
[illegible]erating values are shown. The initial values were: 6.3 v at 2.7 a. See Spec Note 5
[illegible]tial, post vibration, post shock and pre shelf tests were preformed
[illegible] pulse current set at 9.0 amps peak. The tubes were re-read,
[illegible]ting the pulse current at 4.5 mA dc and at two duty cycles.
[illegible] data is shown as pre-shelf #2 and pre-shelf #3 under Osc (3).
[illegible]ate of rise of voltage, rrv = 362 KV/µs for all tests
[illegible]ut terminal pressure test, 12-5-63, revealed zero (0) leakage on the 4 tubes
[illegible]ll tubes were held for 168 hours before qualification testing
[illegible] tubes oscillated satisfactorally at the end of the 90 second warmup
[illegible]eneral note, #73 placed on life test 11-18-64. Four tubes subjected
[illegible] pre-prod testing, three being required. The four tubes passed
[illegible] tests. After 90 day shelf test, all four tubes passed the
[illegible]uired tests under Osc. 2 plus outline dimensions. Tube 74
[illegible] tested additionally under Osc. 1 and 3.
[illegible]be 74 placed on 90 day official shelf life on 12/19/63.

DATA SHEET 8558 MAGNETRON - QUALIFIC

TEST CONDITION	INITIALS	TEST DATE	TEST PHASE	PULSE REPETITION RATE (PPS)	PULSE WIDTH (μS)	DUTY CYCLE	FILAMENT POTENTIAL (VOLTS)	FILAMENT CURRENT (AMPS)	PEAK ANODE CURRENT	OPERATING PE[illegible]	
			SYMBOL →	prr	tp	du	E_f	I_f	i_b	epy	
OSC. 1	LIMITS		MINIMUM	Not Specified	.025	.0003 Nom.	Note 4	Note 4	9.0 Nom.	12.5	3.
			MAXIMUM		.033 Note 2					14.6	-
	R.F.T.	12/9/63	Initial Test	11,200	.022	.00025	2.07	1.3	9.0	13.9	5.
	R.F.T.	12/11	Post-Shock	11,200	.022	.00025	2.07	1.3	9.0	13.9	4
	R.F.T.	12/19	Pre-Shelf	11,200	.024	.00027	2.07	1.3	9.0	13.9	4
OSC. 2	LIMITS		MINIMUM	Not Specified	.06	.0005 Nom.	Note 4	Note 4	9.0 Nom.	12.5	5.
			MAXIMUM		.08					14.6	
	R.F.T.	12/9	Initial Test	6,250	.08	.0005	2.07	1.3	9.0	14.0	9
	R.F.T.	12/10	Post-Vib.	6,250	.08	.0005	2.07	1.3	9.0	14.1	9.
	R.F.T.	12/11	Post-Shock	6,250	.08	.0005	2.07	1.3	9.0	14.0	8
	R.F.T.	12/19	Pre-Shelf	6,250	.08	.0005	2.07	1.3	9.0	14.0	8
	R.F.T.	3/20/64	Final	6,250	.08	.0005	2.07	1.3	9.0	14.0	7.
OSC. 3	LIMITS		MINIMUM	Not Specified	.20	.0005 Nom.	Note 4	Note 4	9.0 Nom.	12.5	5.
			MAXIMUM		.30					14.6	-
	R.F.T.	12/9	Initial Test	2,420	.21	.00051	2.07	1.3	9.0	14.0	8
	R.F.T.	12/11	Post-Shock	2,420	.22	.00053	2.07	1.3	9.0	14.0	8
	R.F.T.	12/19	Pre Shelf #1	2,439	.22	.00053	2.07	1.3	9.0	14.0	8
	R.F.T.	12/19	Pre Shelf #2 NOTE 5	2,420	.22	.00053	2.07	1.3	[illegible]	14.0	8
	R.F.T.	12/19	Pre Shelf #3 NOTE 5	2,280	.22	.0005	2.07	1.3	[illegible]	14.0	8

NOTES: 1. Tests performed 12/4 to 12/6 Witnessed by Simon Zucker, USAE
All tests were witnessed by Harry C. Isaac Jr. OAREF
BOSTON Procurement District
2. Investigation by Eng. personnel indicates a probable re
error in Oscillation (1) pulse width. All Values shou
have been 0.024 microseconds.

WITNESSES: For Signal Corps
Harry C. Isaac Jr.
Simon Zucker USA[illegible] SA.

For Bomac Div
R C Dibley

A

...CATION - QUALIFICATION TEST DATA (note 1) TUBE No. ___

PEAK POWER (partial)	FILAMENT POTENTIAL (VOLTS)	FILAMENT CURRENT (AMPS)	PEAK ANODE CURRENT (AMPS) / PEAK ANODE POTENTIAL (K.V.)	AV. POWER OUTPUT (WATTS)	AV. ANODE CURRENT (mA)	STABILITY & CURRENT STABILITY	SHELF LIFE STABILITY	BANDWIDTH (MCS)	MINOR LOBES (db down)	PULLING FIGURE (MCS)	OSC. FREQUENCY (KMCS)	PUSHING FIGURE	VIBRATION FATIGUE (VIB. & SHOCK)	TEMP. CHANGE °C	FREQ. CHANGE MCS	CALC. TEMP. COEFFICIENT	LOW TEMP. OPERATION i_b (amps)	SHOCK
P_o	I_f	i_b	e_{py}	P_o	I_b		%M.P.	Bw	ML	P.E.	f_o	Push		Δt	Δf	T.C.	i_b	
3.0	Note 4	9.0 Nom.	12.5	3.0		-												
-			14.6	-		1%												
5.2	1.3	9.0	13.9	5.2		OK												
4.0	1.3	9.0	13.9	4.0		OK												
4.3	1.3	9.0	13.9	4.3		OK												
5.0	Note 4	9.0 Nom.	12.5	5.0	4.5	-	-	-	8db	-	69.0		Spec Note 4	-	-	-	9.0 Nom.	Spec Note 3
			14.6		5.5	1%	2%	31.2	-	75	70.5	5		-	-	1.8		
9.0	1.3	9.0	14.0	9.0	4.6	OK		18.0	OK	48	70.08	0						
9.0	1.3	9.0	14.1	9.0	4.5	OK		19.2	OK	48	69.95	0	OK					
8.0	1.3	9.0	14.0	8.0	4.5	OK		20.0	OK	48	70.0	0				1.00	OK	OK
8.5	1.3	9.0	14.0	8.5	4.6	OK		19.2	OK	48	70.2	0						
7.2	1.3	9.0	14.0	7.2	4.4		OK	26	OK	48	70.19							
5.0	Note 4	9.0 Nom.	12.5	5.0	4.5 Nom.													
-			14.6	-														
8.5	1.3	9.0	14.0	8.5														
8.5	1.3	9.0	14.0	8.5														
8.0	1.3	9.0	14.0	8.0														
8.7	1.3		14.0	8.7	4.5													
8.1	1.3		14.0	8.1	4.5													

VIB. PLANE
X_1
Y
X_2
Note

...DE ...an Zucker, USAEMSA

...P. Isaac Jr. QAREP.

...ea a probable reading
...uld values should

...mac Dv

...ibley

3. Plane X_1 is perpendicular to cathode axis and ...
Plane X_2 is perpendicular to cathode axis and ...
Plane Y is parallel to cathode axis and perpendic...
4. Operating values are shown. The initial values we...
5. Initial, post vibration, post shock and pre shelf te...
with pulse current set at 9.0 amps. peak. The tu...
setting the pulse current at 4.5 mA dc and at ...
The data is shown as pre-shelf #2 and pre...
6 Rate of rise of voltage, rrv = 362 KV/μs for ...
7. Input terminal pressure test, n-5-63, revealed ...
8. All tubes were held for 168 hours before qual...
9 All tubes oscillated satisfactorally at the en...
10. General note. #73 placed on life test 11-18-6...
to pre-prod. testing, three being required. Th...
all tests. After 90 day shelf test, all fou...
required tests under Osc. 2 plus outline dim...
was tested additionally under Osc. 1 and 3...
11. Tube 76 carried as a spare... on 90 day shelf...

B

TEST DATA (note 1) TUBE No. 76

K.V.) OUTPUT (3) / ANODE CURRENT (MA) / STABILITY & STABILITY / SHELF LIFE STABILITY / BANDWIDTH (MCS) / MINOR LOBES (DB DOWN) / PULLING FIGURE (MCS) / OSC. FREQUENCY (KMCS) / PUSHING FIGURE / VIBRATION FATIGUE / TEMP CHANGE °C / FREQ CHANGE MCS / TEMPERATURE COEF. CALC. TEMP. COEFFICIENT / LOW TEMP OPERATION i_b (amps) / SHOCK (See data) / VIBRATION BAND WIDTH / HIG. OUTPUT PRESS. (LEAKS) / HOLDING PERIOD / WC [illegible] / OUTLINE DIM. / LIFE

	Z M.P.	B.W.	M.L.	P.E.	f_o	PUSH		Δt	Δf	T.C.	i_b	
-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OK	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OK	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OK	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-	-	-	9 db	-	69.0		Spec Note 4	-	-	-	9.0 Nom.	Spec Note 3
%	2%	31.2	-	75	70.5	5		-	-	1.8		
OK	[illegible]	18.0	OK	48	70.08	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OK	[illegible]	19.2	OK	48	69.95	0	OK	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
OK	[illegible]	20.0	OK	48	70.0	0		[illegible]	[illegible]	1.00	OK	OK
OK	[illegible]	19.2	OK	48	70.2	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	OK	26	OK	48	70.19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

VIB. PLANE	B.W.	ΔP				
	-	-	SEE NOTE 8 BELOW	SEE NOTE 9 BELOW	SEE NOTE 10 BELOW	SEE DATA PAGE 2
	37	0				
		0				
	BAND WIDTH					
X_1	20.0					
Y	23.4					
X_2	19.0					
Note 3						

FIGURE 31

3. Plane X_1 is perpendicular to cathode axis and parallel to output.
Plane X_2 is perpendicular to cathode axis and perpendicular to output.
Plane Y is parallel to cathode axis and perpendicular to output.
4. Operating values are shown. The initial values were: 6.3 v at 2.7a. See Spec Note 4
5. Initial, post vibration, post shock and pre shelf tests were preformed with pulse current set at 9.0 amps. peak. The tubes were re-read, setting the pulse current at 4.5 mA dc and at two duty cycles. The data is shown as pre-shelf #2 and pre-shelf #3 under Osc (3).
6. Rate of rise of voltage, rrv = 362 KV/µs for all tests
7. Input terminal pressure test 12-5-63 revealed zero (0) leakage on the 4 tubes
8. All tubes were held for 168 hours before qualification testing
9. All tubes oscillated satisfactorally at the end of the 90 second warm-up
10. General note, #73 placed on life test 11-18-64. Four tubes subjected to pre-prod. testing, three being required. The four tubes passed all tests. After 90 day shelf test, all four tubes passed the required tests under Osc. 2 plus outline dimensions. Tube 74 was tested additionally under Osc. 1 and 3
11. Tube 76 carried as a spare on 90 day shelf life

C

Tube Nº 73

DATA SHEET - 8558 MAGNETRON
QUALIFICATION TEST DATA - LIFE TEST

INITIALS	TEST DATE	ELAPSED CYCLES	AVE POWER OUTPUT (WATTS)	OSC FREQUENCY (KMCS)	BANDWIDTH (MCS)	STABILITY	PEAK ANODE POTENTIAL (KV)	PEAK ANODE POTENTIAL (KV)
SYMBOL ▸			P_o	f_o	B.W.	-	e_{py}	e_{py}
UNITS	MIN	600	24	68.75	—	—	12.5	12.5
	MAX	-	-	70.75	44	2%	15.0	15.0
TEST COND.			OSC 1	OSC. 2	OSC. 2	2	OSC. 1	OSC. 2
R.F.T.	[illegible]	0	6.2	69.30	20	[illegible]	13.0	13
R.F.T.	11/9/62	59	4.7	69.30	17	OK	13.0	13.[illegible]
R.F.T.	11/26/62	200	4.3	69.58	19	OK	13.	13.[illegible]
R.F.T.	11/29/62	4.[illegible]	.13	69.5[illegible]	5	OK	13.5	[illegible]
R.F.T.	12/4/62	640	2.6	69.60	18	OK	14.0	1[illegible]
R.F.T.	12/[illegible]/62	920	4.[illegible]	69.[illegible]	15	OK	1[illegible]	4.0

WITNESSES: Raytheon Co. | [illegible] Co.

Harry [illegible] — G.H. Rep

Bernard Fisher [illegible]

MOBILIZATION PRODUCTION SCHEDULE AND MAN POWER TIME PLAN TO ACHIEVE PLANNED RATE OF 50/MONTH

The time study work indicates the following monthly man power and new equipment needs to reach the planned rate goal.

1. Supervision

   a. One Engineer
   b. One Shop Foreman
   c. One Machine Shop Group Leader
   d. One Quality Control Inspector

2. Anode Fabrication

   a. Hobbing and grinding hobs. — 1 man

      With additional RF bomber and a set of hob holding dies to provide two press stations.

   b. Anode Machining — 3 men

      With two additional Hardinge Precision Lathes for a total of 3 lathes

   c. Anode Measurement — 1 man

   d. Anode Deburring — 1 man

   e. Anode Potting and Cleaning — 1 man

      With a total of 15 potting molds and one additional potting press.

3. Tube Fabrication

Cathode Assembly	1 person
Body Fabrication	1 person
Exhaust - Final Assembly	1 person
Material Expediting and Processing.	1 person
Inspection	1 person

(with 5 new sets of all jigs and fixtures)

4. Tube Testing

Cold Test	1/2 person
Hot Test	1-1/2 persons

With a wide band low sweep source.

This work force represents a unit cost of approximately $650. per tube for Labor and Overhead. The purchase price for all other parts is estimated to be $500. for each shipped tube at this quantity level. The total estimated manufacturing cost at a steady rate of 50/month then is estimated to be $1,150 not including start up costs and not reflecting expected changes in Labor and Overhead rates.

Reducing this to low quantities and comparing it to the cost of manufacture prior to the PEM Program it is estimated that the low quantity manufacturing cost has been reduced by about 40%.

CONCLUSIONS

The BL-221, 70 Gc 10 kw magnetron can be manufactured to order on a semi-production basis. To achieve the planned rate goal, Step III, implementation would be required.

Storage environment should not exceed 100°F or 95% humidity. For storage periods up to 3 months no seasoning will be required. For longer storage periods seasoning may be required. The tube is capable of operation under field environmental conditions consistent with the specification.

End of life is due to failure of cathode emission. All tubes at end of life have copper deposition on the emitter and this copper is obviously coming from the vane tips. Life test evaluation was done at 0.07 μsec pulse width.

A user contemplating a long pulse field condition for this tube should recognize that long pulse life capability has not been evaluated and if cathode emission life is limited by vane tip errosion then life would be shorter at long pulse.

SECTION 3

QUALITY CONTROL AND YIELD

SECTION 3 - FINAL REPORT

IN PROCESS INSPECTION AND QUALITY CONTROL

The following chart lists the construction, inspection, test and rework steps planned to fabricate 600 finished tubes. The run is broken into two parts consisting of one initial run and one rework run.

Operation	Inspection	Acceptable Units	Parts available after first run for rework run	Reason for Rejections
Raw Part and Material Inspection	per Part Spec.			
Anode Fabrication				
Hob and machine 3000 slugs	Metalurgical analysis of raw material Visual	2400	---	- End of hob life. - Improper Stripping - Torn or bent vanes.
Dimension and Cold Test 2400 anodes	Comparator and Low Power Electrical	1200	---	- Dimensional Errors - Frequency - Circuit Q's
Body and Envelope Ass'y.				
1200 units through two furnace brazes	Visual solder flow. Leak detect.	1150	340	- Incomplete or excess solder filleting
Cathode Bushing Furnace Braze 840 units	Die test a sample and perform tear test on ceramic metalizing band. Leak detect 100%		810	- Vacuum leaks

Operation	Inspection	Acceptable Units	Parts available after first run for rework run	Reason for Rejections
Main Stems Furnace braze and RF braze 840 units	Concentricity Leak Detect Sample Test Ceramic Bond	810	60 sleeve and cup parts	Vacuum Leaks Concentricity
Heater Cathode Mechanically assemble and spot weld 810 units	Heater Continuity Coating Hardness Wire Brittleness Cathode Temp.	810 (expect to lose 30 heaters, hats and emitters)	360 heaters, emitters and hats	Soft heater coating. Cracked emitters. Brittle Wire.
Furnace Braze 1800 windows	Die Test sample Leak Detect Measure VSWR	1200	390	High VSWR Vacuum Leaks
Furnace Braze 1200 exhaust caps	Visual	1200	390	Imperfections in Gland Nut
Exhaust 810 units	Review of Exhaust Data	790	20	Leakers or gassiness. Insufficient Emission.
Furnace braze and assemble 720 couplers	Visual - sorting is done at test.	650	175	Poor output match
Test 790 Units	All electrical and outline requirements of T.S.	475	315	Frequency Power Spectrum

Salvage all external hardware, couplers, main stems, exhaust pole pieces, cathode bushings.

Operation	Inspection	Acceptable Units	Parts available after first run for rework run	Reason for Rejections
Perform rework on 340 units including resorting of window and couplers for best match.	Repeat	150	0	Frequency Power Spectrum
Life and Design Sample Testing of 625 Units	Per T.S.	600	0	Destructive Testing

APPENDIX I

BL-221 SPECIFICATION

Type BL-221

*The applicable provisions of the latest issue of MIL-E-1 pertain to this specification.

Description: Magnetron, pulse type, millimeter wave length, fixed frequency 69.0 to 70.5kMc, 10 kw peak, air cooled, permanent magnet.

Ratings (abs.):	Ef	epy	ib	pi	Pi	Du	tp	prr	tk	T
Units:	V	kv	a	kw	W	---	μs	pps	sec	°C
Max:	7.0	15.0	10.5	158	87	.00055	0.30	17,000	---	100
Min:	---	---	---	---	---	---	0.025	---	75	---

Ratings (abs.):	rrv	tfv
Units:	kv/μs	μs
Max:	350	.25
Min:	100	---
		Note 18

Interrelation of Parameters - Note 13

Typical Operation:	If	ib	epy	tp	prr	rrv	tfv
Units:	A	a	kv	μs	pps	kv/μs	μs
Osc. 1	1.1	9.0	14.0	0.03	10,000	325	.20
Osc. 2	1.3	9.0	14.0	0.07	7,150	325	.20
Osc. 3	1.5	9.0	14.0	0.25	2,000	325	.20
	Note 5					Note 17	Note 18

Altitude: Notes 2, 1

Weight: 7.5 lbs (max.)

Mounting Position: Any

Ref.	Test	Conditions	Min.	Max.
4.5	Holding Period:	t = 1.8 hours	---	---
4.9.2	Dimensions:	Per attached outline Fig.'s 1, 2, 3, 4	---	---
---	**Shock	No voltages; 50 G; 4 ms duration. Note 3	---	---
----	**Vibration:	Osc. . Note 15	BW: ---	3.0/tp Mc

	SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
Page 1 of 9	Type BL-221	9-23-63

Ref.	Test	Conditions		Min.	Max.
4.9.14	**Temperature Coefficient:	Osc. (2); T 30°C to 100°C at point specified in Figure 1	ΔF/ΔT:	---	1.8Mc/°C
4.9.11	Waveguide Output Pressure:	45 psia; Note 2		---	---
----	Input Terminal Pressure:	Note 1		---	---
4.9.15	**Low Temperature Operation:	Osc. (2); tk = 90 sec's. (max.) T = -55°C at point specified in Figure 1		---	---
4.10.8	Heater Current:	Ef = .3V tk = 90 sec's. (min.)	If:	2.5	3.0A
----	**Vibration Fatigue:	Heater Voltage only; 10G; F = 0; duration 15 min. Note 4		---	---
4.16.3	Oscillation (1):	σ = 1.2:1 (max.)		---	---
4.16.3.2	Heater Cathode Warm-up Time:	Ef = .3V; Note 5	tk:	---	90 sec's.
4.16.3.3	Pulse Characteristics	tp = 0.03±.005μs; Du = .0003 rrv = 325 kv/μs (min.); Notes , 17		---	---
4.16.3.4	Average Anode Current:	Note 1		---	---
----	Peak Anode Current:	ib = 9.0a		---	---
4.1 .3.5	Pulse Voltage:	----	epy:	12.5	14. kv
4.1 .3.6	Power Output:	Within 100 sec's.	Po:	3.0	--- W

Ref.	Test	Conditions	Min.	Max.
	*Stability	Notes 9, 10	---	1.0%
4.16.3	Oscillation (2):	σ = 1.2:1 (max.)	---	---
4.16.3.2	Heater Cathode Warm-up Time:	Ef = 6.3V; Note 5	tk: ---	90 sec's
4.16.3.3	Pulse Characteristics:	tp = 0.07±0.01μs; Du = 0.0005; rrv = 325 kv/μs (min.); Notes 6, 17	---	---
4.16.3.4	Average Anode Current:	Note 1	Ib: 4.5	5.5mAdc
----	Peak Anode Current:	ib = 9.0a	---	---
4.16.3.5	Pulse Voltage:	----	epv: 12.5	14.0kv
4.16.3.6	Power Output:	Within t= 100 sec's	Po: 5.0	--- W
4.16.3.7	R. F. Bandwidth:	Notes 7, 8, 9	BW: ---	2.5Mc / tp
----	Minor Lobes:	Notes 7, 8, 9	Ratio: 8.0	--- db
----	Stability:	Notes 9, 10	Missing Pulses: ---	1.0%
4.16.5	Pulling Factor:	ib = 9.0a; Note 9	ΔF: ---	75 Mc
4.16.6	**Pushing Factor:	ib = 8.0 to 9.0a;	ΔF: ---	5 Mc/a
4.10.7.3.1	Fixed Tuned Frequency:	ib = 9.0a;	F: 69.0	70.5kMc
----	**Shelf Life Stability:	t = 90 days; Notes 10, 11	Missing Pulses: ---	2.0%
4.16.3	Oscillation (3):	σ = 1.2:1 (max.)	---	---
4.16.3.2	Heater Cathode Warm-up Time:	Ef = 6.3V; Note 5	tk: ---	90 sec's

Ref.	Test	Conditions	Min.	Max.
4.16.3.3	Pulse Characteristics:	tp= 0.25±.05μs; Du= 0.0005 rrv = 325 kv/μs (min.) Notes 6, 14, 17	---	---
4.16.3.4	Average Anode Current:	ib = 4.5mAdc	---	---
4.16.3.5	Pulse Voltage:	-----	epy: 12.5	14.[illegible]kv
4.16.3.6	Power Output:	Within t = 100 sec's	Po: 5.0	--- W

ACCEPTANCE LIFE TESTS

Ref.	Test	Conditions	Min.	Max.
4.11	Cycling Life Tests:	Group D σ = 1.5(min.) with phase varying thru a minimum of 1/2 λ approximately every 15 min.; Notes 9, 12	Cycles: 500	---

Conditions	ib	Ef	Duration
Standby	---	6.3V	3 minutes
Osc. (2)	9.0[illegible] Note 1	Note 5	18 minutes
Off	---	0V	9 minutes

Ref.	Test	Conditions	Min.	Max.
4.11.4	Cycling Life Test End Point:	-----	---	---
		Power Output Osc. (1):	Po: 2.4	--- W
		Frequency Osc. (2):	F: 68.75	70.75kMc
		R.F. Bandwidth Osc. (2):	BW: ---	3.5Mc / tp
		Stability Osc. (2)	MP: ---	2.0%
		Pulse Voltage Osc. (1):	epy: 12.5	15.0kv
		Pulse Voltage Osc. (2):	epy: 12.5	15.0kv

NOTES:

Note 1: In place of measuring and setting the operating point on the basis of average anode current, the peak anode current shall be measured and adjusted to the specified value. This may be accomplished by use of (1) an oscilloscope and conventional peak current viewing resistor network if available and convenient or, (2) a circuit which will produce a peak current readout on an instrument suitable for field use or, (3) the specific circuit shown and described under Appendix A.

Note 2: At peak power levels of 10 kw or more, the waveguide output must be pressurized at not less than 2 psig using dry air or a dry gas at a pressure providing an equivalent breakdown capability. The waveguide pressure must not exceed 45 psia. See Note 9 for special requirements under mismatch conditions. The waveguide output system shall be pressure tested by the application of air by way of a proper pressure test fitting. There shall be no leaks as indicated by the formation of bubbles when liquid soap or detergent is applied to the joints associated with the waveguide output system.

Note 3: a. - This test shall be performed on a Naval Research Laboratory standard shock machine for electron devices. A resilient cushion (see note 3b) shall be interposed between the hammer and anvil of the table and a suitable hammer angle selected to produce a shock of the specified magnitude and duration (see note 3c). The mounting plate of the tube shall be bolted with brass bolts to either the table or the standard angle bracket, depending upon the direction of the desired shock, using a 1-9/16 inch thick brass spacer between the tube mounting plate and the table or angle bracket. The shock shall be measured on the brass spacer. The table shall be given one shock in each of the following directions:

1 - Paralleled to the cathode, with the cathode terminals pointing away from the hammer.

2 - Perpendicular to the cathode axis and waveguide axis.

3 - Perpendicular to the cathode axis and parallel to the output waveguide axis.

b. - A resilient cushion, consisting of 9/32 inch thick rubber sheet of thirty Shore Durometer hardness, covering the entire anvil of the table, has been found to produce the specified shock duration under the given conditions of table load and shock magnitude.

Note 3 (continued):

c. - Because of the varying resilience of the tube on its mounting plate with different shock directions and the high ratio of tube to table weight, the hammer angle will vary with the tube's orientation to produce the required magnitude of shock.

d. - Criteria for passing Shock Test: After the Shock Test, the tube shall show no mechanical failure and shall meet all electrical requirements of the tube specification sheet with the exception of life tests.

Note 4: The direction of vibration shall be in a plane perpendicular to the axis of the cathode. There shall be no evidence of heater-cathode or cathode-anode shorts during this test.

Note 5: Starting heater voltage shall be [illegible].3 volts. Upon application of high voltage, the applied heater voltage shall be immediately reduced to the value shown in the tube data sheet. (Refer to "Typical Operation" for values of heater current to be used as a guide).

Note 6: The voltage rate of rise shall be measured between [illegible]0 and 90% of the peak voltage forward slope.

Note 7: The tube shall be operated into a transmission line of VSWR of 1.5:1 adjusted in phase to produce maximum spectrum degradation.

Note 8: A suitable spectrum shall be considered as one in which the major lobe has a shape such that its slope does not change sign more than once for power levels greater than the specified ratio (db) below its peak.

Note 9: The waveguide system including the pulling section must be pressurized, with dry sulfur hexafluoride (SF_6) gas at 3 psig or equivalent whenever measurements are being made of pulling, life tests, and other measurements where the VSWR of the load at the magnetron output flange is 1.3:1 or more.

Note 10: Stability shall be measured in terms of the average number of output pulses missing expressed as a percent of the number of input pulses applied during the period of observation. The missing pulses (M.P.), due to any causes, are considered to be "missing" if the RF energy is less than 70% of the normal energy level in the range of [illegible]9.0 to [illegible]0.5kMc. The VSWR of Note 7 shall be adjusted to that phase producing maximum instability and the

Note 10 (cont'd)

missing pulse counted during any five minute interval of a ten minute test period.

Note 11: The missing pulse test of Osc. (2) shall be the first one performed after the specified shelf life.

Note 12: Air cooling will be adjusted so that the anode block temperature as measured at the specified point runs at 90° C or at the maximum temperature it will reach in the absence of cooling, whichever is lower.

Note 13: These ratings are interrelated, but it does not necessarily follow that combinations of limits can be attained simultaneously.

Note 14: Magnetrons should be operated by gradually increasing the applied pulse voltage to the operating point to avoid any excessive arcing.

Note 15: Vibration frequency will vary from 10 to 50 to 10 cps at a displacement of ±.04" (or .08" peak to peak) at a uniform rate in not less than 10 minutes. The test will be performed along each of three mutually perpendicular axes.

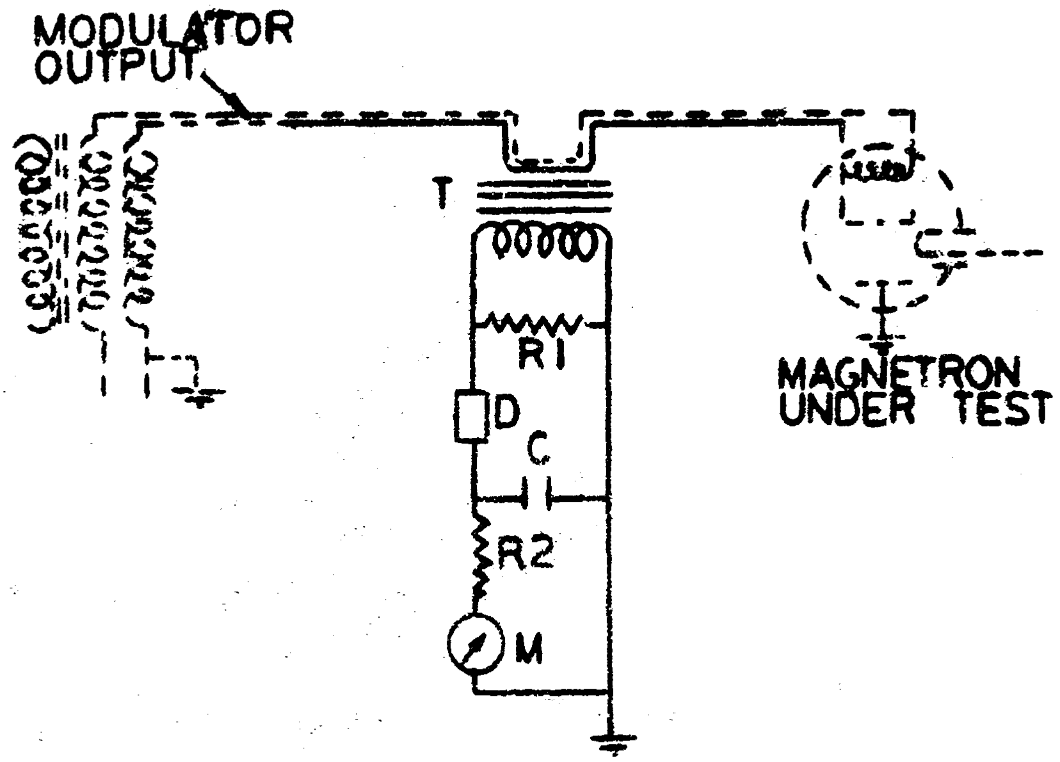
Note 16: The cathode input terminal will operate up to 6,000 feet without pressurization. Above that altitude an equivalent pressure must be provided for the terminal. The cathode terminal shall be pressure tested by the application of air by way of a proper pressure test fitting. There shall be no leaks as indicated by the formation of bubbles when liquid soap or detergent is applied to the several joints adjacent to the tube mounting plate.

Note 17: The minimum rate of rise of voltage (rrv) shown is for hard tube modulator operation. For soft tube modulator operation, the rate of rise of voltage should not be less than 100 kv/μs. The minimum values shown under the Osc. tests must not be exceeded by the user and shall be exceeded by the manufacturer.

Note 18: The time of fall of voltage shall be measured as the slope of a line between 20 and 85% of the peak on the trailing slope of the voltage pulse.

Appendix A

Peak Current Indicating Circuit



T = Special pulse current transformer
- a. Primary = 1 turn, bifilar for this application
- b. Secondary = 5 turns #14 magnet wire
- c. Core = Special Ferrite, Ferroxcube #203F250-3C or equivalent

R_1 = Non-inductive resistor network, 10-240 ohm composition resistors in parallel resulting in 24 ohms total. Resistors = MS35043-71-RC20GF241J

D = Ultra-High Conductance Diode, IN3730

C = Low inductance capacitor, .25 µfd Sprague Hypass #48P12 or equivalent

R_2 = Resistor, 1 megohm, 1 watt, MS35044-173-RC32GF105J. Note 1

M = Indicating meter, 0-50 µa, MR-36W-050-DC-UAR

Note 1: Use of a 10 megohm resistor and a 0-5 µa meter will provide reduced inherent error

TENTATIVE	SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
	Type BL-221	9-23-63

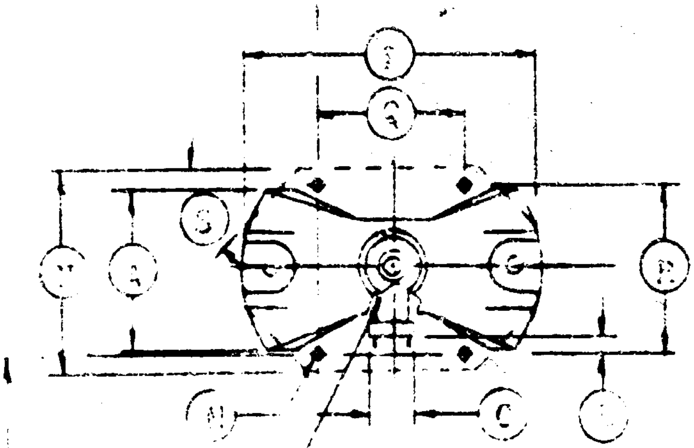
W-101

A pulse current of 10 amperes flowing in the primary circuit of the pulse current transformer induces a current of 2 amperes in the secondary circuit. A pulse voltage of 50 volts appears across resistor R_1. Condenser C is charged to essentially a D.C. voltage of 50 volts by way of the diode D. The D.C. voltmeter consisting of multiplier R_2 and micorammeter M indicates this D.C. voltage of 50 volts. This is representative of the 10 peak amperes of primary pulse current.

In practice, the indicated output is slightly less than the theoretical 50 volts, due to transformer losses, diode forward voltage drop and discharge of the condenser C during the interpulse period. Each instrument should be caliberated periodically to ensure continued good accuracy. The one turn primary may consist simply of the passage of the cathode and heater leads, properly insulated for high pulse voltage, through the hole in the core Since the pulse current to be measured has a negative polarity, the proper orientation of the primary and secondary windings, polarity of the diode and of the indicating instrument must be observed.

Note:- Mounting plate is shown in phantom.

Reference Plane "B"

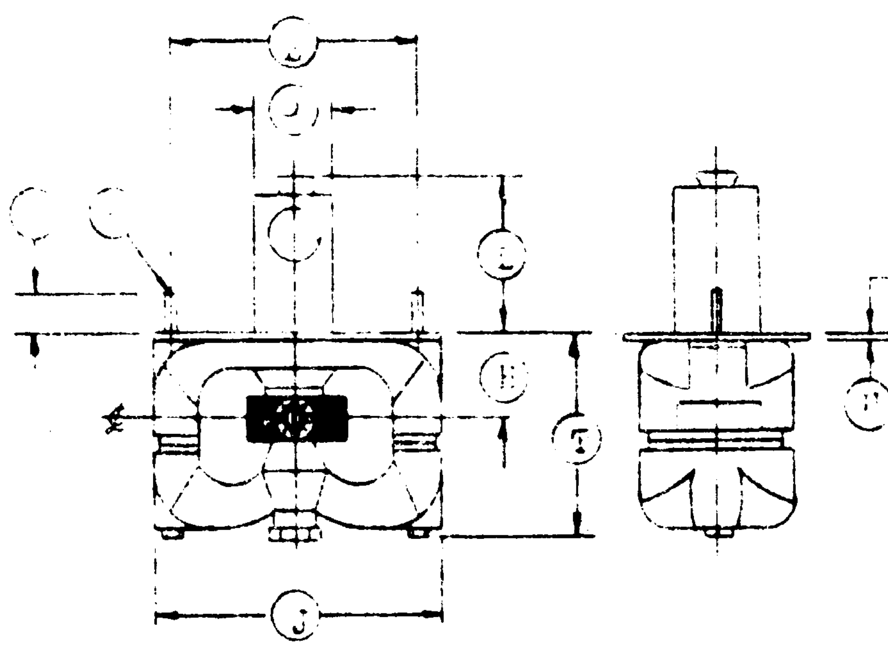


Reference Plane "C"

"T" Anode Temperature Test Point (on anode body adjacent to output flange).

Ref.	Dimension in Inches
A**	3.037 Max
B	0.454 ±.030
C**	0.750 ±.005 Dia
D**	1.750 ±.010 Dia
E	4.633 ±.030
G**	0.0[illegible]7 Min
H	1.634 ±.030
J**	5.7[illegible]2 Max
K	5/16-18NC
L**	2.375 Max
M	0.266 Dia Drill
	4 Holes
N**	4.000 ±.020
P**	5.500 ±.020
Q	3.000 ±.010
R	[illegible].000 ±.010
S**	4°
T**	4.032 Max
U**	0.250 ±.010

Note:- Axis of waveguide flange must lie parallel within ±.010 to Planes A and B.

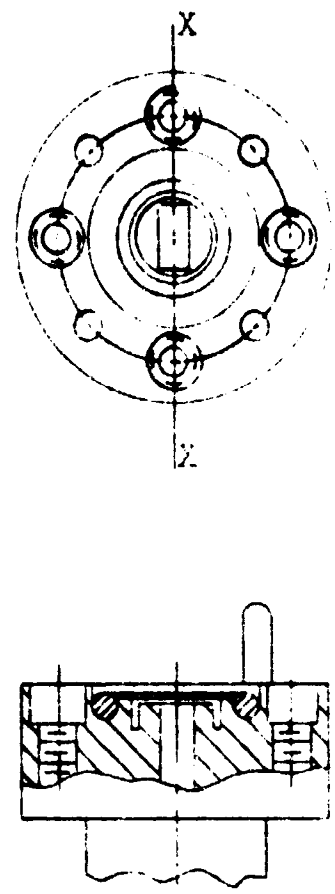


Reference Plane "A"

Figure 1

	SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
Tentative	Outline BL-22[illegible]	12-20-60 clr

Outline Includes Terminal Connection, Output Flange #1, and Mating Waveguide Flange #1



Note 1:- Centerline X-X must lie parallel to Plane within ± 1/2°. Refer to Page 1 of Outline.

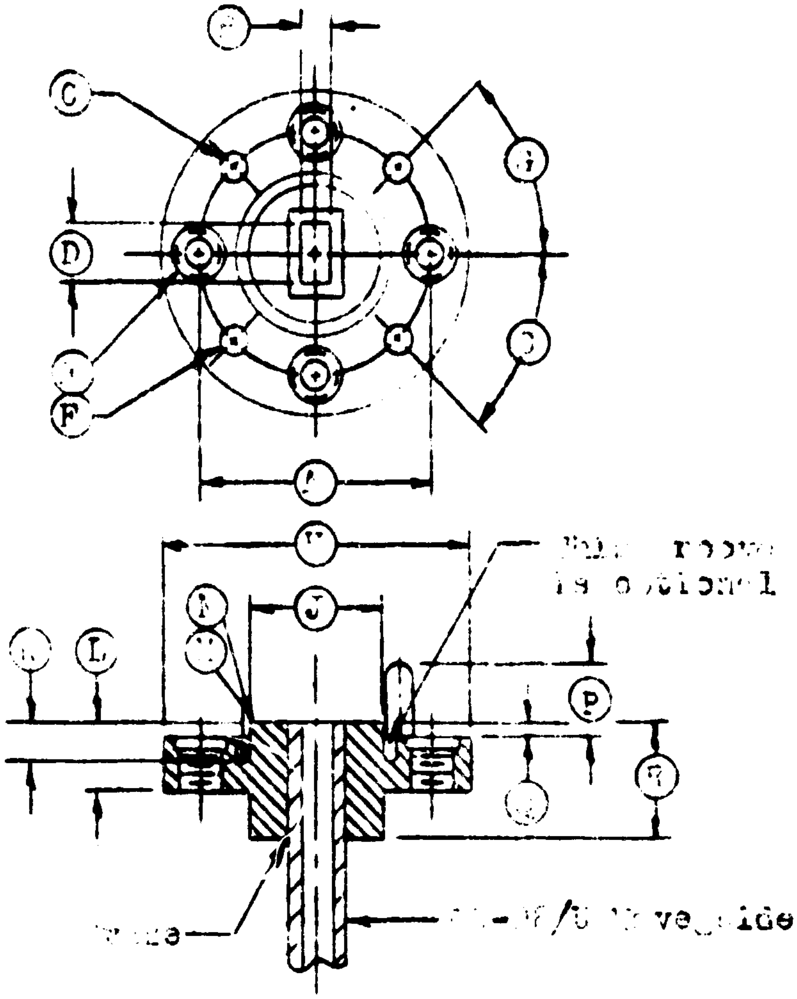
Note 2:- This flange must mate with modified Mating Waveguide Flange #1, Type [illegible]

Note 3:- Material is rhodium plated brass.

Used for following tubes :- BL-221, BL-240

Figure 2

SPECIFICATION SHEET	BOMAC LABORATORIES INC SALEM ROAD BEVERLY MASSACHUSETTS
Output Flange #1	clr



Ref.	Dimension in Inches	Ref.	Dimension in Inches
[illegible]	0.632 ±.003 [illegible]	[illegible]	45° ±15'
[illegible]	0.074 Ref.	[illegible]	0.750 ±.005 Dia.
C	0.0[illegible] ±.0005 Di[illegible].	J	0.32[illegible] +.010 -.000 Dia.
	[illegible] holes [illegible] Apart	K	0.0[illegible] Ref.
[illegible]	0.14[illegible] Ref.	L	0.1[illegible] +.010 -.00[illegible]
[illegible]	#4-40 [illegible] Thread	[illegible]	0.015 Rad.
	0.140 Dia. [illegible]	[illegible]	0.010 Max. Rad.
	0.03[illegible] ±.005 [illegible]	P	0.172 ±.010
	[illegible] holes	[illegible]	0.0[illegible] ±.001
[illegible]	[illegible] +.00[illegible] -.000 Dia.	[illegible]	[illegible] Ref.
	[illegible] 180° Apart		

[illegible]

Note:- [illegible]

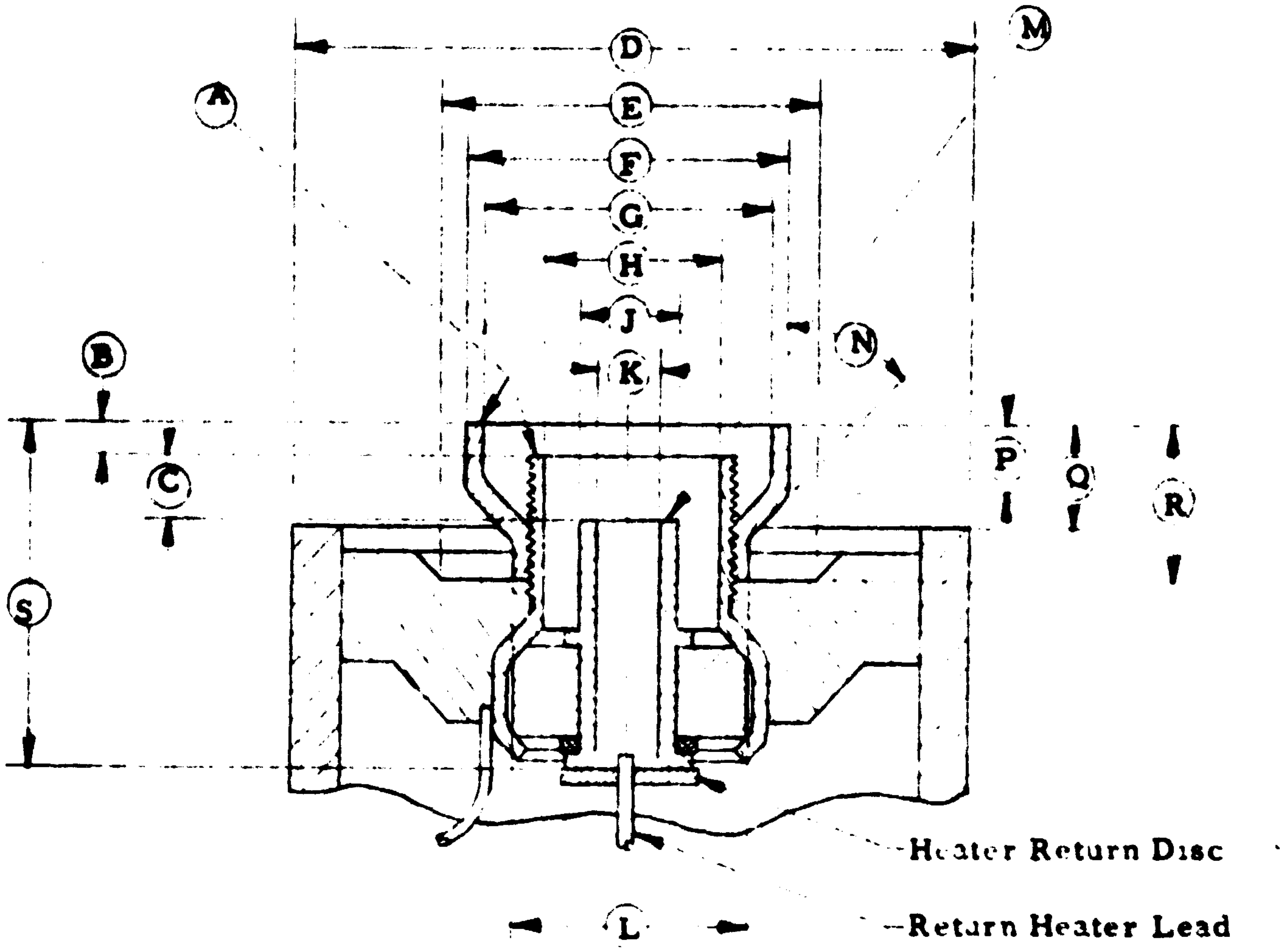
Used for following tubes:-

BL-221, [illegible]L-2[illegible]6

Figure 3

SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
Mating Waveguide Flange #1	[illegible] - [illegible]

DEFIANCE NO. 187H [illegible]



Ref.	Dimension in Inches
A	Heater - Cathode Common
B**	0.075 Min.
C**	0.150 ±.005
D**	1.750 ±.005 Dia.
E**	1.000 ±.010 Dia
F**	0.845 Max. Dia.
G**	0.735 +.010 -.005 Dia.
H**	0.531 ±.003 Dia.
J**	0.250 ±.005 Dia.
K**	0.169 ±.005 Dia.
L**	0.700 Max. Dia.
M	Heater Return
N**	45° Approx.
P**	0.150 ±.005
Q**	0.180 ±.020
R**	0.360 ±.020
S**	0.[illegible] Min.

Used for following tubes:-
BL-246
BL-221

Figure 4

	SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY MASSACHUSETTS
TENATIVE	Terminal Connection for Heater - Cathode	12-20-60 LJB